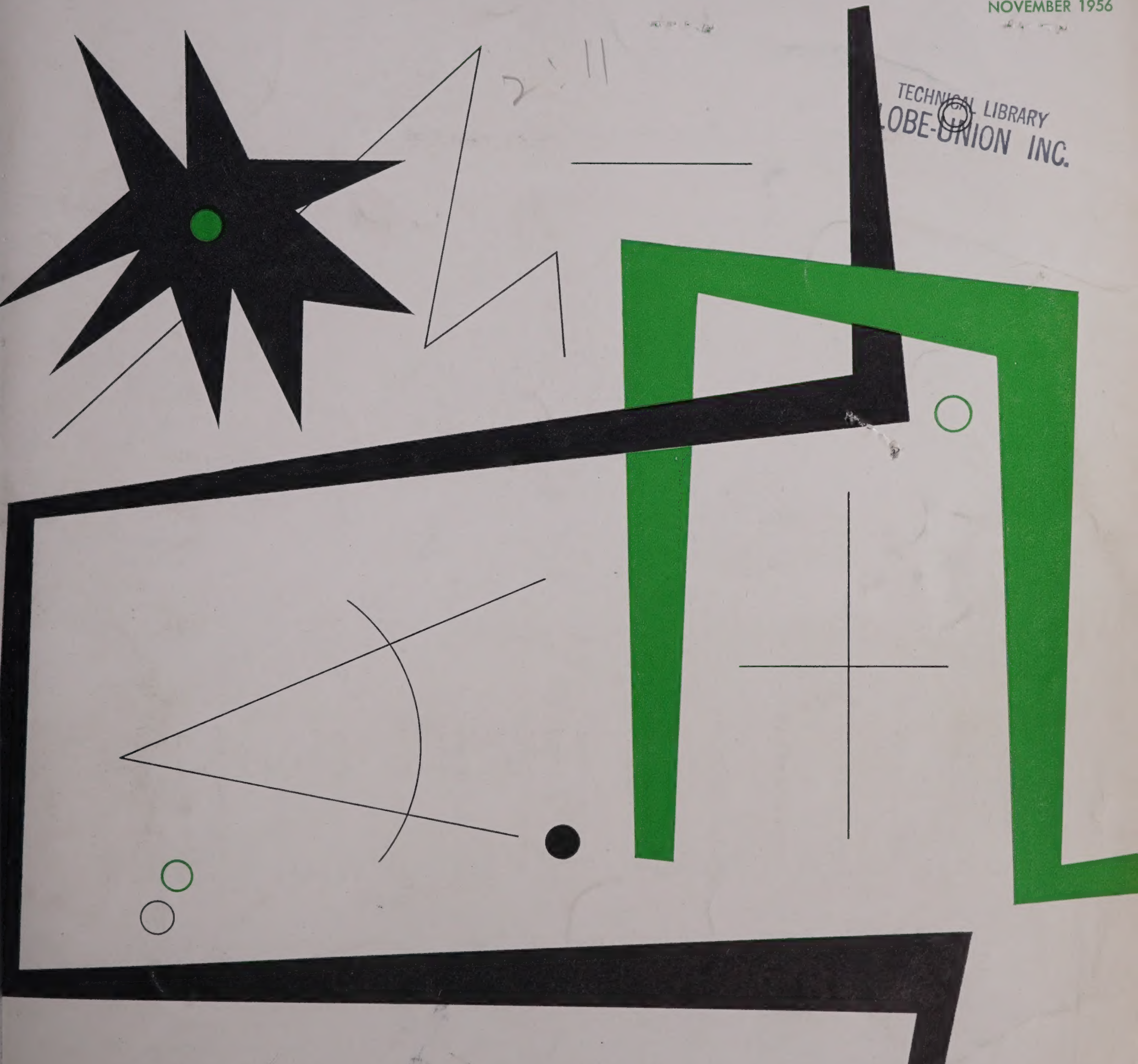
R/E RESEARCH & ENGINEERING

FOR RESEARCH & DEVELOPMENT MANAGERS

NOVEMBER 1956

TECHNICAL LIBRARY
GLOBE-UNION INC.

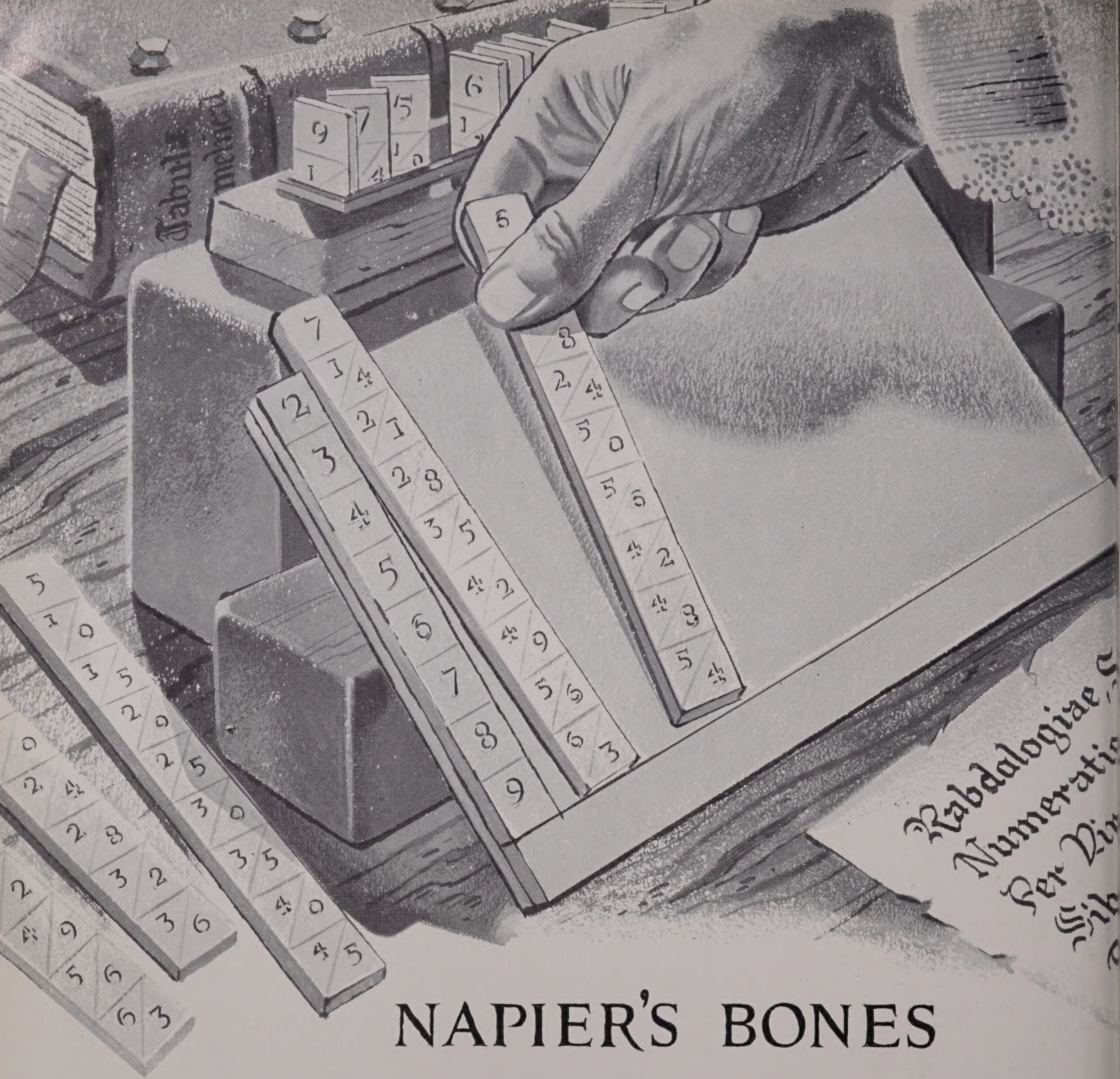


Wall Street Looks at R/D

The Cause and Cure of Executive Insomnia

The Conceptual Obstacle Course

New Highs in Low-Temperature Engineering



NAPIER'S BONES

...UNIVAC—17th Century Style

The first "automatic calculator" was a device known as "Napier's Bones", brain child of John Napier, the Seventeenth Century discoverer of logarithms.

The computing art has an interesting history . . . but the most interesting pages are being written right now by the engineers and technicians at Remington Rand UNIVAC.® The electronic computing systems they design and build are revolutionizing techniques in scientific research, communications, transportation, quality control and everyday procedures in modern business. First in the electronic computing field, UNIVAC is the first choice of men seeking challenging assignments, early recognition and rewarding incomes. Find opportunities unlimited . . . at UNIVAC.

®Registered in U.S. Patent Office

IMMEDIATE OPENINGS FOR:

MECHANICAL ENGINEERS: Graduates BS and MS levels. For development of automation instruments . . . computer input and output mechanisms . . . memory devices. Includes paper and magnetic tape handling equipment, punched card equipment, printers, magnetic storage drums, and machine design in mechanical and electro-mechanical fields.

DESIGNERS: With or without formal degrees if qualified. Here are the foremost opportunities to achieve full stature in small mechanisms work. Includes diversifications of both mechanical and electro-mechanical equipment.

Send Complete Resumé to

Remington Rand Univac

DIVISION OF SPERRY RAND CORPORATION
Dept. NN-22
WILSON AVENUE • SOUTH NORWALK, CONNECTICUT

NOVEMBER 1956 Vol. 2, No. 11

RESEARCH & ENGINEERING

THE MAGAZINE FOR RESEARCH AND DEVELOPMENT MANAGERS

Editorial: Wm. H. Relyea Jr., Publisher; Melvin Mandell, Editor; Scott Nicholson, Associate Editor; Lawrence Sandek, Associate Editor; Luis J. A. Villalon, Management Affairs Editor; Dr. Merritt A. Williamson, Contributing Editor Dr. R. C. Vickery, Contributing Editor

Art Director: Kelly Miller

Publishing Manager: Walter L. Benz

Advertising Offices

NEW YORK CITY—Alfred Malecki, 103 Park Ave., New York 17, N.Y., LExington 2-0541

NEW ENGLAND & NEW YORK STATE—Victor Raiser, 103 Park Avenue, New York 17, N.Y., LExington 2-0541

NEW JERSEY & EASTERN PENNSYLVANIA—Duncan Macpherson, 126 Summit Ave., Jenkintown, Pa., TUrner 4-0810

CLEVELAND—Fred Grant, 11820 Edgewater Drive, Cleveland 7, Ohio, ACademy 1-6858

CHICAGO—R. Jerome Claussen, Rm. 534, 53 W. Jackson Blvd., Chicago 4, Ill., WAbash 2-7838

LOS ANGELES—Wilbur Menne, Jack Follansbee, Arden Parkes, The Menne Co., 1127 Wilshire Blvd., Los Angeles 7, Calif., MUtual 4191

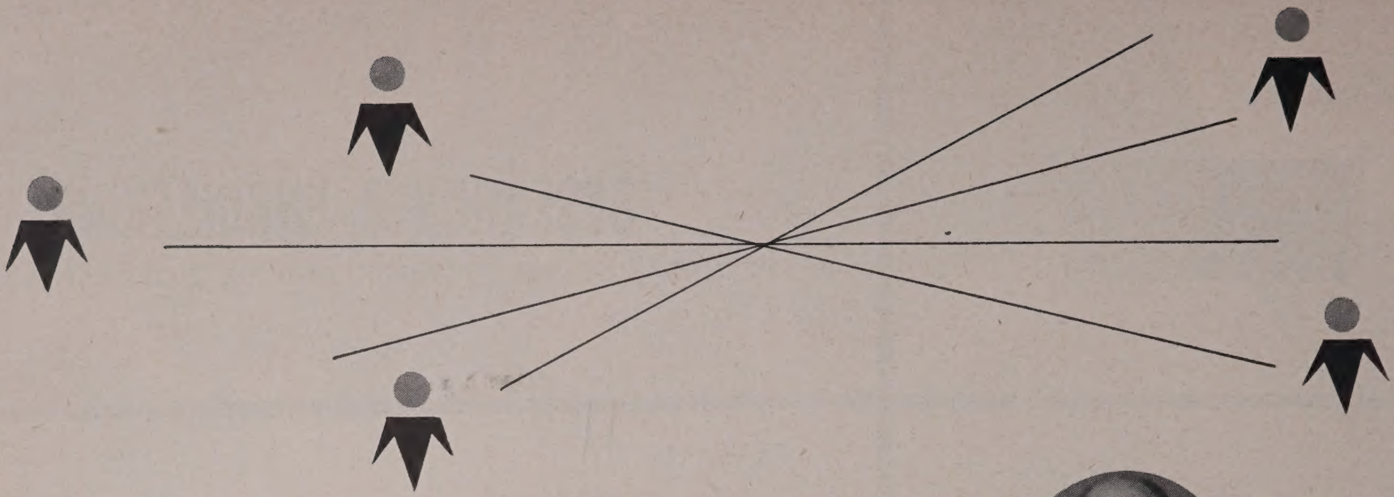
SAN FRANCISCO—Robert Zunich, The Menne Co., 114 Sansome St., San Francisco 4, Calif., GArfield 1-3846

FEATURES

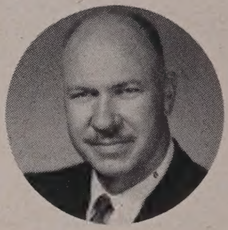
DEPARTMENTS

Over 28,000 circulation

RESEARCH & ENGINEERING IS CIRCULATED TO MEN IN CHARGE OF INDUSTRIAL RESEARCH, DEVELOPMENT AND DESIGN DEPARTMENTS IN ALL BRANCHES OF INDUSTRY AND IN GOVERNMENT RESEARCH INSTALLATIONS. SUBSCRIPTION. U. S. A. AND CANADA, $10.00 ANNUALLY; OTHER COUNTRIES, $20.00 ANNUALLY, SINGLE ISSUE $1.00 WHEN AVAILABLE. PUBLISHED MONTHLY BY THE RELYEA PUBLISHING CORPORATION, WILLIAM H. RELYEA, JR., PRESIDENT; EXECUTIVE, ADVERTISING AND SUBSCRIPTION OFFICE: 103 PARK AVE., NEW YORK 17, N.Y. LE 2-0541. EDITORIAL OFFICE: 77 SOUTH STREET, STAMFORD, CONN., FIRESIDE 8-7781. UNSOLICITED MANUSCRIPTS MUST BE ACCOMPANIED BY RETURN POSTAGE. ALTHOUGH ALL REASONABLE CARE WILL BE TAKEN, THE EDITORS ASSUME NO RESPONSIBILITY FOR THEIR SAFETY OR RETURN. ALL EDITORIAL COMMUNICATIONS SHOULD BE SENT TO THE STAMFORD OFFICE. PUBLISHED AND ACCEPTED AS CONTROLLED CIRCULATION PUBLICATION AT ORANGE, CONN. COPYRIGHT 1956, THE RELYEA PUBLISHING CORPORATION. THE TRADEMARKS R/E AND RESEARCH & ENGINEERING ARE THE PROPERTY OF THT RELYEA PUBLISHING CORPORATION, REGISTERED WITH THE U. S. PATENT OFFICE.



TECHNICAL MANAGEMENT



MERRITT A. WILLIAMSON

One of the many subjects which should occupy the technical manager's thoughts is ethics. I wish to consider ethics in the light of a definition given by Webster—"a system of moral principles". Consideration of ethics and ethical conduct is usually associated with the professions: law, theology, medicine, pedagogy and, perhaps, the most recent profession, engineering. Definite ethical codes have been formulated for the older professions. Violators may be debarred, unfrocked, forbidden to practice or to teach.

The persons who mete out these punishments, however, are representatives of the professions themselves, not the public at large. The code of ethics has the effect of law for those practicing the profession, but is not usually incorporated in the law of the land. Upon entering a profession people agree voluntarily to abide by its code. Our laws, however, are obeyed by virtue of our citizenship or residence whether we like them or not. Business is not usually considered a profession, although schools like the University of Chicago in their Executive Program are trying to train their students to regard their work professionally.

A profession is characterized and delineated by two aspects: (1) It means that the practitioner has acquired a fund of special, organized, theoretical learning and has had appropriate training while acquiring the knowledge. (2) It means that the practitioner recognizes his responsibility to clients, employers, associates, employees and the general public. In short, it means that a professional man is working for more than the financial remuneration. Inherent in every profession is a code of ethics. Certain codes may be written, such as the Oath of Hippocrates, others are generally "understood". Ethical conduct, however, is not confined to the professions. Each person of character has a system of moral principles by which he lives. What is a reasonable code of ethics for a technical manager? Perhaps some formal statement may have been evolved, but I am unaware of any. There are many issues which might be included. Perhaps some organization of technical managers might undertake the formulation of a code so that business management as a whole might know the things that their R/D men in good conscience cannot do.

Ethics for Technical Managers

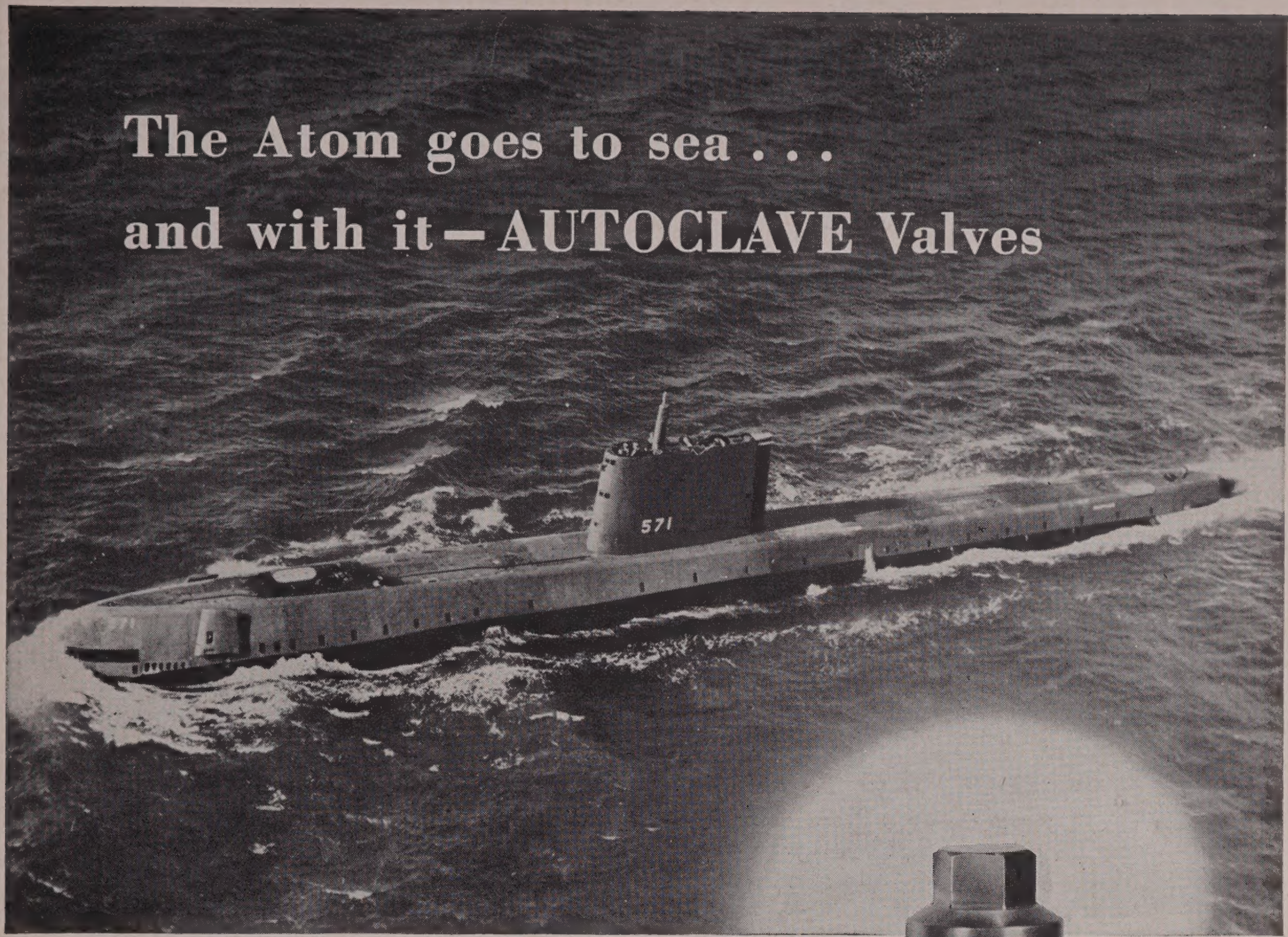
It is not my purpose to evolve a set of ethical principles for technical managers but rather to call attention to the need on our part for being aware of the obligations that we have to insure that our affairs are conducted in a truly ethical manner.

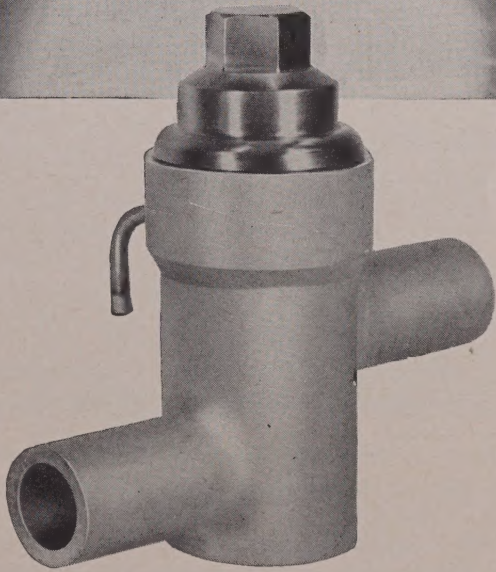
How does a technical manager acquire a sense of professional ethics? We take persons out of school, bring them into our companies and place them with others on our staff, taking for granted that they will somehow learn to behave in a manner befitting scientific gentlemen. Perhaps we assume that their college or university has trained them in the elements of professional conduct. If we do, perhaps we are making a mistake. Some schools do provide lectures on the subject, and, of course, all institutions are operated so that cheating is penalized, but I think we are wrong if we expect the educators to do the complete job of ethical education. Obviously, it began in the home when the student was a child. In the course of instruction any situations that might be proposed would have very little meaning to students, who have never been in industry. It is in industry where emphasis must be given, and I think no training program is complete without some time devoted to the importance of ethical behavior.

True, there is no such thing as a dishonest scientist or engineer in the area of his technology or science. His published work or his reports definitely show whether or not he is intellectually honest. The open and free criticism of the scientific meeting and press determine the lasting quality of his work. But how about his moral integrity? Do we place young men with those who are apt to encourage the cribbing of ideas from others without acknowledgment? How many people have you known who have taken credit when it was not due or have presented some idea as their own which you know they received from someone else? How many people do you have that have daily contact with young engineers, and whose point of view is so basically selfish that they cannot or will not accept a management dictum which is in the broad interest of the organization if it involves their own loss of prestige or power? The beginning worker may feel that something is not fair or right, but he can easily quell his scruples if he is led to believe that this is the "business world" now and that a different code applies.

If we give no thought to integrity and ethical conduct in our organizations, should we not foresee a situation generally where top management finds itself distrusting its scientific and engineering workers? At best the area of research and development is difficult to explain to the non-technical man. Personal integrity of the manager is vital in getting management to go along with excursions into unknown areas. In my opinion the encouragement of a real sense of ethics on the part of our employees is of extreme importance. If you are doing anything about it or have any suggestions on what might be done, please write to me so that we can share them with other readers.

(Continued on page 4)





THE world's first atomic powered underwater ship—United States Navy Submarine Nautilus—carries within her hull, special valves engineered and manufactured by .

The same engineering skill and craftsmanship which contributes to the maritime alertness of the Nautilus, is available to you in meeting the problems of your research and development work. Consult with us on your pilot plant and laboratory requirements for high pressure equipment.

SPECIALISTS IN LABORATORY AND PILOT PLANT HIGH PRESSURE EQUIPMENT

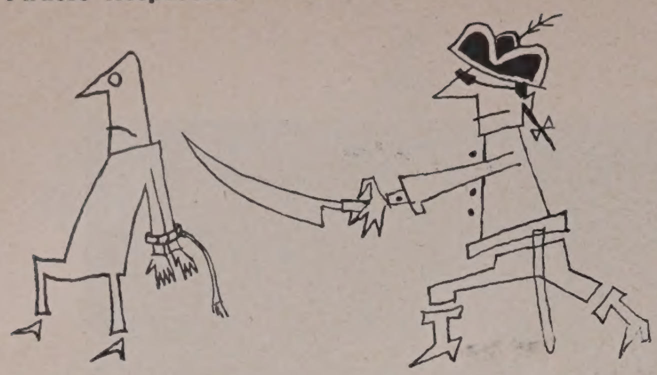
AUTOCLAVE ENGINEERS ERIE, PA.

AUTOCLAVE ENGINEERS

2930 WEST 22ND STREET • ERIE, PENNSYLVANIA

FOR MORE INFORMATION CIRCLE 2 ON PAGE 48.

Are Pirates Respected?



Employment practices of a company provide one way by which a company is judged by the world at large. Unfortunately many recruiting practices are branded unethical without any real violation of any code. This has been a matter of concern among R/D directors and it has even been suggested in some meetings which I have attended that committees be formed to prepare a code of ethical employment practices. To the best of my knowledge this has not yet been done, although I do know of some companies which have prepared statements of policy to be followed by their recruiters. These statements emphasize the obligation to the person being considered for employment, so that a man will not be offered a job if he is basically not suited to the company's needs. Enlightened recruiting dictates that the recruiter be more of a counselor to the person seeking employment than a salesman for the company. Counselling should be carried even to the point of advising him what other companies might offer better opportunities. Although a quota to be filled is a real incentive for the recruiter to bring in "bodies", the best interests of his own company and society at large are served if no misfits are employed. This avoids the wasted time and effort required to get rid of an unsatisfactory employee. There may be resultant damage to him which can affect his home life and his performance on future jobs. I am sure each one of us can think of examples of such mishandling.

A Question of Ethics

The case this month bears on the problem of ethics. John Hull is a clever and imaginative engineer but is young and needs several more years of guidance under a mature leader before he can attain his maximum effectiveness. He is, of course, ambitious, and feels that he is being "kept down". Attempts have proven unsuccessful in getting across to him that he lacks certain experience to make him a good supervisor. He is paid more than any of his contemporaries. It so happens that in the city where he works a former employee of his company, Mr. Ingle, has established an agency. Mr. Ingle reasoned that there would be a profitable business in hiring engineers and then renting them out on jobs. He has offered to double John's salary and he has a ready place to rent him out for 5000 more dollars than he must pay him. John is interested. He is young, although married and a father. He likes the idea of more money, greater diversity of work and feels that he should take advantage of the opportunity to hire out to the other company, which is local, through Mr. Ingle's agency.

If you were John Hull's boss and he came in to talk to you about making a change, what would you advise him? If he decided to leave you, would you recommend him for rehire if he should want to come back? Do you think he is behaving in an ethical professional manner? Would you be ethical if you recommended against his rehire? Is Mr. Ingle ethical in the whole transaction? Is the company which will employ Hull through the agent acting ethically? This situation seems to offer an opening for particularly lively and enlightening discussion.

More on Servocomp

An interesting commentary on this case has been received from L. G. F. Jones of the Air Arm Branch of Westinghouse Corporation. He divides the considerations into matters of principles and personalities concerned. He writes: "It would appear that the following principles were violated:

"1. 'Don't rock the boat' i.e., it is not desirable to make major changes in an organization except for reasons (usually pressing) of present or future health.

"2. 'Hold your fire until you see the whites of their eyes' i.e., major organizational changes should not be announced until they have been sufficiently studied so that a thoroughly acceptable set of guiding principles for the changes have been defined. It seems apparent that the president's redefinition does not suit the requirement, if only because the line of demarcation between research and engineering is notoriously hard to define.

"3. 'Don't send a boy to do a man's job' i.e., for planning the redistribution between Research and Engineering Departments, a chairman (preferably impartial—but not necessarily so) should have been appointed for the planning group with sufficient time available and authority to carry through the necessary studies. By making this man solely responsible for getting out the plan in a given time, it is possible to assure results when needed.

"4. 'Don't delay' i.e., once a change has been announced to an organization, the time until it is executed should be minimized. Two to three weeks is a common limit on this.

"5. 'Lay down the line' i.e., people—and especially professional people—should be informed as soon as possible whether or not they are likely to be involved in a prospective change. Since the 100 people in the Research Department and 100 of the 300 in the Engineering Department were definitely unaffected, this would have alleviated the situation somewhat.

"6. 'Take it easy' i.e., wherever possible, it is desirable to achieve major changes as the culmination of a long series of minor changes and rearrangements. There is no indication in the description of the case that such an approach would be unsatisfactory."

He goes on to write that "Unquestionably, the reasons for these 'violations of principle' lay in the personalities involved. The large size of the Engineering Department can certainly be considered as indicative of the efforts and organizing ability of its head (with no reflection whatever intended toward the head of the Research Department). Such a man would not easily agree to a major reduction in his department.

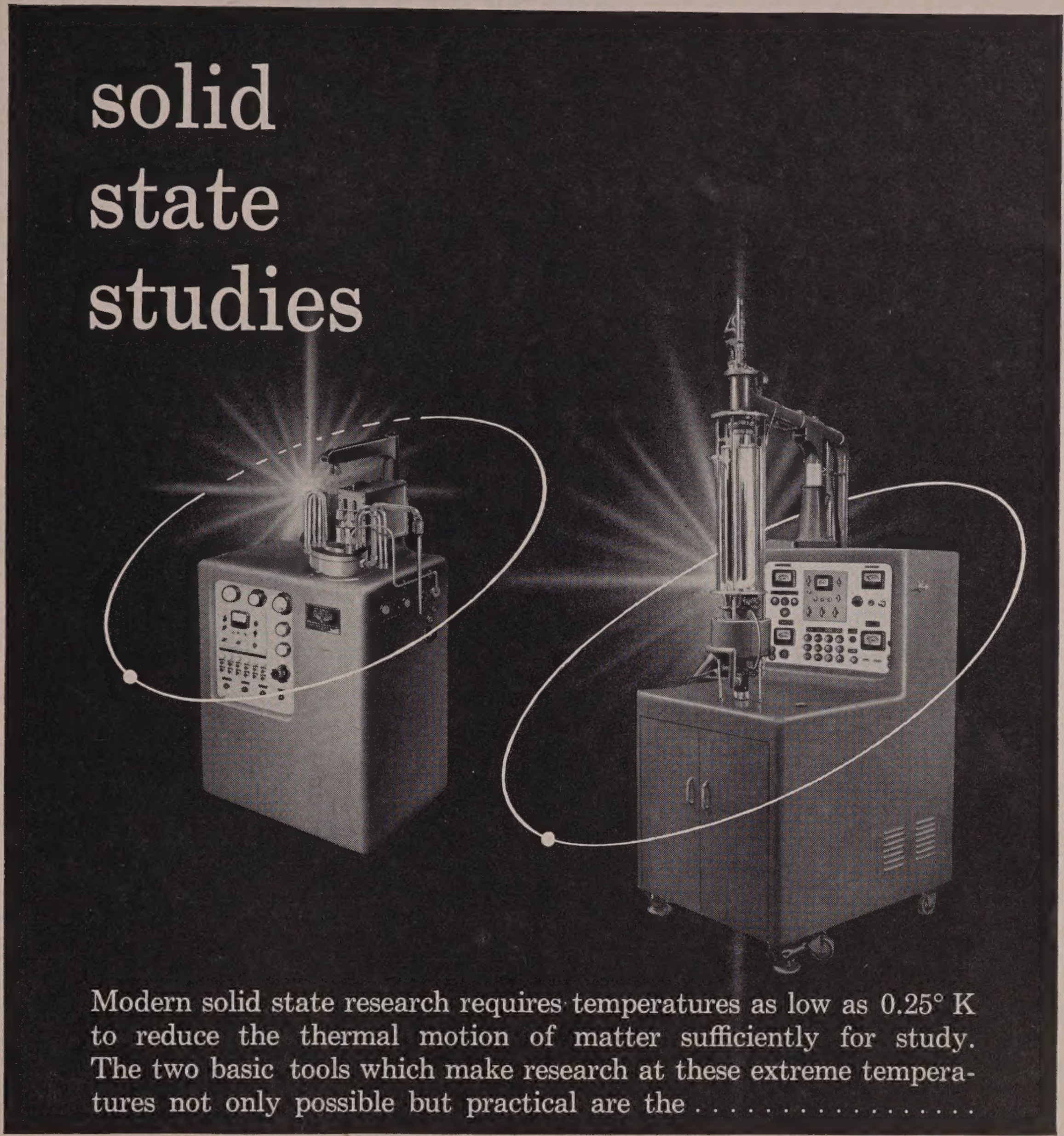
"The failure of the president to call the Executive V.P. into the planning is most peculiar, and would seem to indicate a consistent schism over this matter. In this split, it would appear that the President and the Research Director were on one side, and the Executive Vice President and the Engineering Director on the other.

Bingo Corporation

Maurice Nelles of Technicolor Motion Picture Corporation, Hollywood, Calif., writes that this is a typical situation existing for research managers and further states that he feels it is a problem of their own making.

"If you were to ask me what is the greatest handicap that Research Directors have, I would say it is their mental block on speeding up research and development activities. They have taken the easy course of action, which is to let the development develop itself rather than employ the more professional method of planning the development or research and eyeing it critically to see what can be speeded up and how. The old cliche that research cannot be programmed or hurried is an iron curtain to the progress of research methods.

"In the [Bingo Corporation] case obviously the original idea was an excellent one, but the organization of the research group was such that the idea could not be implemented in the minimum time. Instead, it was necessary to allow time for self-education of the individuals concerned, to enable them to accomplish work they were incapable of doing at the time. I am acquainted with many instances where an entire organization would work on a project for many months, only to achieve a certain result which a single individual would achieve in half an hour. It is situations such as these that make it imperative for management to double check their research managers."



ADL Collins Helium Cryostat and the ADL Magnetic Refrigerator.

ADL Collins Helium Cryostat (*left*) produces liquid helium, which makes low temperature studies possible. Maintains even test chamber temperature down to 2° K. Equipped with automatic controls. Easy to operate and completely safe because non-toxic, non-combustible helium is the only circulating gas.

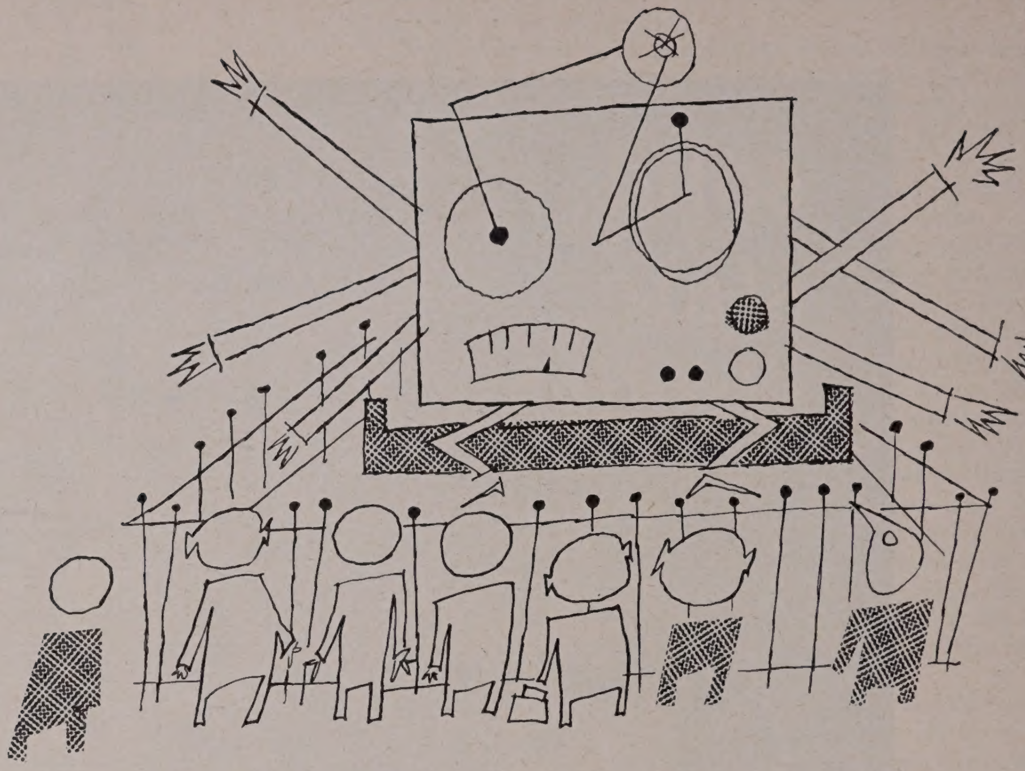
ADL Magnetic Refrigerator (*right*) maintains constant temperature at any reading between 1° K and 0.25° K. Extreme low-temperature range provides opportunities for many solid state studies which up to now have been impossible. Completely automatic operation requires no exceptional skill.

Write for complete information . . . . Arthur D. Little, Inc.

30 MEMORIAL DRIVE, CAMBRIDGE 42, MASS.

FOR MORE INFORMATION CIRCLE 3 ON PAGE 48

Taking Human Engineering Away from Us Humans



A few years ago Dr. Ross Gunn, the physicist, then associated with the Naval Research Laboratories, was attending a dinner at Ohio State University. Seated beside him was an inquisitive faculty wife. First she turned to the gentleman on her other side, a famous surgeon, and asked what he did. His answer was, "I'm a thyroid surgeon!"

Then she turned and asked, "And what do you do, Dr. Gunn?"

He replied, "I'm a Naval physicist!"

Her reaction, according to legend was, "Isn't that carrying specialization a bit too far?"

We believe that George A. Peters, Jr., a "human engineer" at Picatinny Arsenal, is carrying specialization a bit too far when he proposes ". . . some formal organization of human engineers". Writing in the October 1956 issue of *Mechanical Engineering,* Peters laudably pleads for making human engineering an "integral" part of the college engineering curriculum. But when he calls for an organization of human engineers he is aiding in the "disintegration" of the engineering profession. Human engineering and any other discipline or technique that broadens an engineer and makes him more aware of the entire problem should be one of the tools of the trade. Setting up a special group of engineers and scientists as human engineers would tend to make the technique a specialty, the secret rite of its devotees.

The leaders of our technical community such as President Killian of M.I.T. have all been chorusing the need for teaching more scientific and engineering fundamentals in engineering schools and less of the specialized arts of the branches of technology. Human engineering is or should be used by all engineers and is now becoming one of the fundamentals, according to Peters. We agree!

Peters says that the proposed organization would provide "some opportunity for communication and expression . . . ." among all the engineers, psychologists, psysiologists, mathematicians and medical men now practicing human engineering. There are more than enough engineering and scientific societies and publications to make such an interchange easy. The engineering societies are only too willing to cooperate in co-sponsoring special symposia and meetings devoted to subjects of mutual interest. We are sure that they could be persuaded to co-sponsor meetings on human engineering with the societies of psychologists and physiologists. They already have the machinery, personnel and experience. And of course the society and technical magazines are ready to publish good papers on any subject that interests their readers, especially such a vital and topical one as human engineering.

Zworykin's Proposal

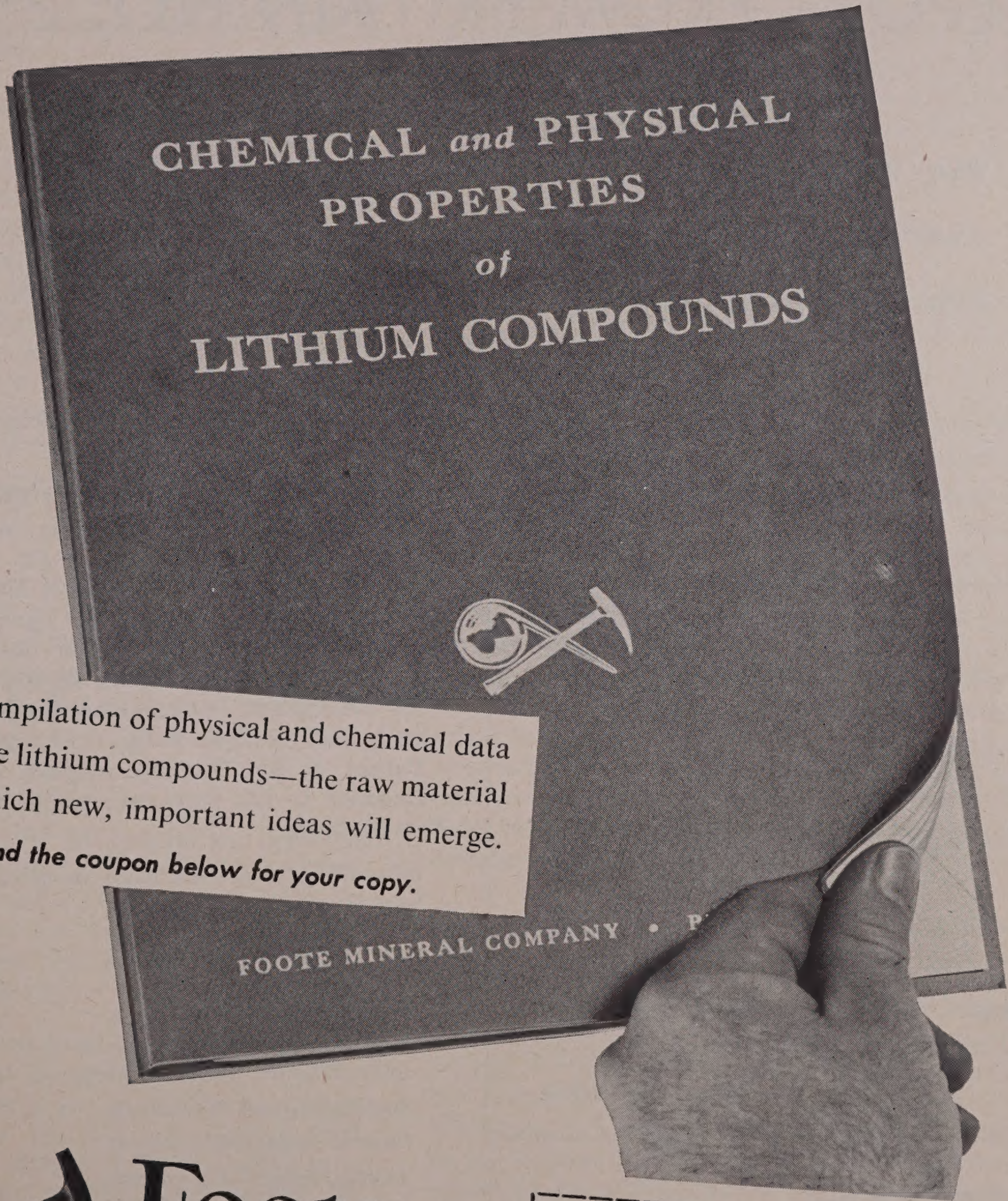
Much the same criticism would apply to the proposal of Dr. Vladimir K. Zworykin of RCA at the last IRE Convention that a special organization be established to encompass the engineers devoted to "medical electronics". Although Zworykin's proposal is more conventional because it is based on a class of equipment rather than a technique.

Project Peters' proposal to its logical end and nearly all engineers and scientists would be officers in national societies or their local chapters. The great American pastime of organizing and running clubs would be carried too far if an everyday tool is canonized into the status of a sacred relic to be caressed only by the recognized faithful.

Melvin Mandell

EDITOR

Available from Foote...



. . . a compilation of physical and chemical data on Foote lithium compounds—the raw material from which new, important ideas will emerge.

Send the coupon below for your copy.

Foote
MINERAL COMPANY
455 Eighteen West Chelten Building,
Philadelphia 44, Pa.

RESEARCH LABORATORIES: Berwyn, Pa.

PLANTS: Exton, Pa.; Kings Mountain, N.C., Knoxville, Tenn.; Sunbright, Va.

FOOTE MINERAL COMPANY
455 Eighteen W. Chelten Bldg., Phila. 44, Pa.

Please send me a copy of the booklet "Chemical and Physical Properties of Lithium Compounds."

Name ____________________

Title ____________________

Company ____________________

Address ____________________

____

FOR MORE INFORMATION CIRCLE 4 ON PAGE 48.

Developments

REPORT FROM BRITAIN NO. 2

- **Where the R/D Money Goes**
- **Ahead of U.S. in Radioisotope use**
- **British Electronic Developments**

Comparison of British and American R/D expenditures at current rates of exchange. The periods covered are April 1955 to March 1956 for Great Britain and 1953 for the United States, the latest figures available.

	BRITAIN	U. S. 1953
Total Expenditures (in Millions)	900 ± 225	5000
Percentage Govt. Work	60%	34%
Percentage of Gross National Product	2%	1.5%
Full-Time Employees in R/D	106,000	400,000
Professionals in R/D	30,000	157,000
Cost Per Capita	\$19.6	\$33.6

Aviation is the Fat Boy in R/D

Exactly opposite to the situation here, the aircraft industry in Britain leads electrical equipment in R/D expenditures by private industry. Since the British auto industry is so much smaller than its American competitor, it is not surprising that British chemicals are the third biggest spenders, way ahead of automobiles and shipbuilding and engineering. A tabulation of R/D expenditures is shown right and a comparison of British R/D cost with similar American expenditures is given above.

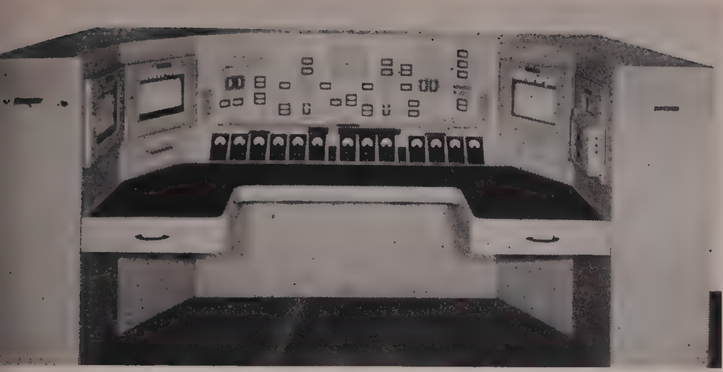
The comparison is based on the preliminary estimates compiled by the British Department of Scientific and Industrial Research. Some revisions are expected when the final results are available.

British Lead U.S. in Radioisotope Analysis

The British lead this country in using radioisotopes for general analysis according to Dr. O. K. Neville, Technical Director of Nuclear Instrument and Chemical Corporation, Chicago, Illinois. Dr. Neville spoke on this subject before a recent meeting of the ASTM. As an example he cited the termination of naphthylene in coal tar already worked out by the British. The radioisotopes are used in a general analytical method called "isotope dilution". Dr. H. S. Turner at the National Physics Laboratory, Teddington, England is the man responsible for the naphthylene determination.

Tabulation of R/D costs yearly by private industry in Britain in millions of dollars.

Industry	Expenditure
Aircraft	252
Electrical engineering	90
Chemicals and allied trades (other than mineral oil refining)	56
Engineering and shipbuilding	36.3
Vehicles (other than aircraft)	16.3
Textiles, leather and clothing	15.1
Mineral oil refining	8.65
Other manufacturing	7
Iron and steel	7
Food, drink and tobacco	6.7
Other metal goods	5.9
Precision instruments, jewelry etc.	5
Non-ferrous metals	4.75
Wood, cork, paper and printing	4.2
Treatment of non-metalliferous mining products (other than coal). Bricks, china, glass cement etc.	3.5



m the careful placement of indicators with flow diagrams super-
oosed, it is apparent that Britain is up with the United States in the
nan engineering of process control panels. This panel is made by
rshed & Vignoles, Ltd., London.

dio Research in Briitain Covers Spectrum

From studies of very low frequencies for navigation to g-distance v-h-f propagation, the entire radio spectrum under investigation in Great Britain. At the Radio Re-rch Station at Slough, frequencies of 15kc are being con-ered for long-distance navigational aids. Not enough is own about long-distance propagation at this frequency, ere the behavior of the ionosphere is important. The time l space variations of phase and amplitude of the field have be taken into account and a detailed knowledge of phase iations is essential to the development of a phase-com-rison system. Equipment is under development to enable nparisons of phases to be made at two receiving stations lely separated from a single distant transmitter.

miconductors

The behavior of germanium in the form of rectangular nocrystalline filaments and in diodes and transistors is a me subject at the Station. The noise characteristics of manium are of particular interest and observations of spectral density of noise in filaments and in point-con-t and junction rectifiers biased in the reverse direction ve been made.

rrites

operties and preparation of ferromagnetic materials under study at the Imperial College of Science and Tech-ogy. Single crystals of certain ferrites are in demand for damental measurements at extremely high frequencies l a crystallization technique has been developed for the duction of small single crystals.

am Swinging in the Microwaves

Artificial dielectrics capable in prism form of changing direction of a radiated beam as its frequency changes also being worked on at the Imperial College. Such sms used in conjunction with a frequency modulated nsmitter could produce very rapid beam swinging. An ficial dielectric has been developed which, in the form 52 degree prism, will scan the emerging beam over 15 rees by a five percent change in frequency. A greater m swing for a given change in frequency is desirable and her work is in progress.

g Hop Transmissions

t the Station in the course of experiments on back-scat-from the ground at high frequencies it was found that ing the winter echoes ocurred apparently corresponding ong hops much greater than the usual maximum of 4000-for a single hop. Although the hops cannot be explained yet, they may be due to some form of propagation requiring no intermediate ground reflections. Experiments are now under way to compare back-scatter of this type with field strength measurements of signals from radio transmitters at various distances along the same great-circle path.

In collaboration with the Post Office (which handles wireless communications there) an investigation has been made of the propagation of very high frequency waves by means of scattering in the ionosphere to distances of the order of 1000 to 2000km. A signal transmitted by this process is of extremely variable amplitude but, at least to 10Mc, there is always present a residual or background component, provided high power and a sensitive receiver are used. The work has shown that the range of frequencies likely to be most useful for practical applications of this mode of propagation is about 25 to 60Mc. It is possible to maintain a continuous frequency shift telegraph circuit on a limited scale using scatter propagation, but continuous telephony is much more difficult.

Closed Systems

One of the problems that must be solved before men can travel in space ships is the disposal of human wastes. In a tightly sealed space ship, untreated liquid and solid wastes from the human body would soon become a danger to life. To simply discharge the materials from the ship may be unwise because of the effect on the carefully plotted flight path. The Air Force has assigned New York University engineers and scientists to study the problem.

The answer may lie in processing the wastes so that they could be partly reused for fuel or to help grow dietary supplements. Several years of basic research will be needed before the researchers can even begin to design equipment to solve the problem, according to Prof. William T. Ingram, director of the project. The wastes can't be burned because precious oxygen would be consumed. Small plants like algae might be grown as a supplement to the crew's diet in treated wastes. Since algae need carbon dioxide to grow, they would remove some of that unwanted gas from the air supply. Solar heat bearing down on one side of the ship might conceivably incinerate or chemically "crack" waste material.

Index of Return on R/D

How do you total up the gains R & D has made for a company? That question has puzzled top management, research & development administrators and comptrollers for as long as formal R & D programs have existed. No method yet proposed will find favor with most cost accountants, since none will produce dollar values that can be supported in the manner to which accountants are accustomed. Consequently, no present method of evaluating R & D will provide numbers that can be shown as part of a corporate financial statement.

According to Fred Olsen, Vice President for Research of Olin Mathieson Chemical Corp., New Haven, Conn., the first concern of R & D management is to develop a set of yardsticks that can be used by those who have the obligation to protect corporate earnings. For his own use, moreover, the R & D director needs a tool that will allow him to gage each project, and to combine these individual project evaluations into a single overall index.

Olsen has developed an "Index of Return" on R & D expenditures which essentially provides a system of assign-

ing values to three different types of projects:

- Process savings
- New products
- Improvements in the quality of present products

Process savings are fairly easy to determine, Olsen says. When a formal technical proposal is offered by research to production to alter an existing process, it is simple to have a team of cost accountants measure all the pertinent factors as they exist prior to introduction of the new process. These will include such items as amounts of raw materials, steam, power, and water consumed, the direct labor, the maintenance labor and supplies, and other factors. Three months later the same items are measured and the difference is assumed to be due to the new process.

In the case of a new product, the Index of Return can be recorded fairly simply for a period of years after sale of the product is initiated. One factor that must be carefully noted is whether or not sale of the new item has diminished the sale of some old item which has been displaced by the change. With an improved product, the situation is much more complex. Actually, no method has yet been found for reliable quantitative evaluation of a product improvement.

Applying an Arbitrary Yardstick

After trying many unsuccessful schemes, it was decided to apply a purely arbitrary yardstick to measure improved products, as, for example, the annual sales value of a product recorded for two years. Obviously, Olsen says, the value of the improvement is related to the volume of sales. The percentage of annual sales value and the time of recording is perhaps not too important; the main thing is for top management to agree to adopt this arbitrary measure, and to recognize that in using it the company is dealing with an abstract quantity rather than with a precise and identifiable dollar earning. That is why the term Index of Return was adopted.

Olsen says that in Olin Mathieson, the Index of Return is computed by adding together:

- The value of each process saving for a period of one year
- Three percent of the sales value of each new product each year for five years
- Two percent of the sales value of each improved product each year for two years.

This total Index of Return is plotted in comparison with the amount spent for R & D.

At Olin experience has shown that it is extremely important not to refer to this Index of Return as some sort of credit to the R & D department. Actually, there is *no return from research and development* unless the factory produces the new or improved product and sales markets it. Almost always, it is the engineering and production departments who work out the bugs in the process. The Index is therefore a measure of the effectiveness of the total team effort involved in developing, making and selling a product.

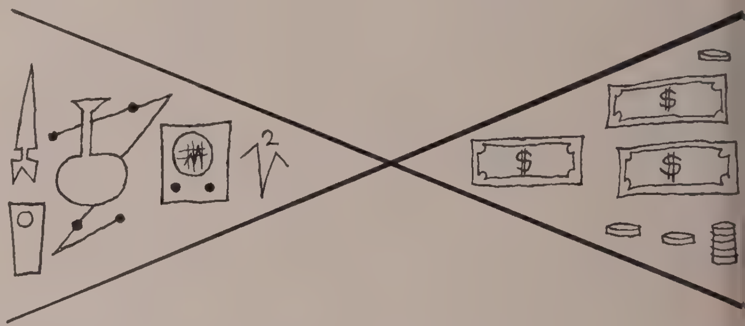
Gaging the Potential Value of R & D

In addition to indicating the value of R & D projects already accomplished, the Index has perhaps an even more valuable application—that of helping to gage the potential value of R & D not yet completed or even started. The same personnel who are skilled in the methods of computing the Index of Return for completed projects can apply thes same technics to estimating the Index for projects on whic R & D is proposed.

For example, when a large number of projects is bein considered for the next year's budget, the Index of Retur is estimated for each item. Those projects which do nc show a high enough ratio of return can be sorted out an rejected. The formula for estimating the value of a nev project is as follows:

$$\frac{\textit{Estimated Index of Return X Probability of Success}}{\textit{Estimated Cost of R \& D}}$$

Experience has shown that this ratio should exceed or the project is too poor a prospect to warrant muc further consideration. For example, suppose the estimate Index for a new product is 1,000,000; the probability of at



taining a successful result is thought to be 1 in 3. Henc not more than $100,000 should be spent on the project.

According to Olsen, this calculation should be made sev eral times during the early stages of the project when th probability of success is more difficult to estimate. If th ratio drops below 3, then the item should be rejected unles special considerations warrant its retention.

No formula can be a substitute for mature judgmen But the discipline of going through these computations wi assure that ample consideration has been given to the ec nomic aspects of a project.

A More Flexible Type of Index

Experience indicates the desirability of a more flexib type of Index, involving to a still greater degree the judg ment of the men managing the projects. Such an Inde would be the sum of:

- process savings for three years (instead of one year)
- three percent of sales for three years for improved proc ucts (instead of two percent of sales for two years)
- three percent of sales for five years for new products.

To avoid distortion of the Index by including a percentag of sales of a widely sold article where the improvement trivial, the R & D manager recommends and the genera manager of the Product Division approves the percentag to be employed for each project and the number of yea it should be computed.

By applying the yardstick of the Index of Return, th R & D manager disciplines himself to give adequate ec nomic consideration to each project. The general manage is likewise obliged to state his judgment as to the signif cance of each research project, and to endorse the value applied to completed projects. Finally, top management i presented with an over-all survey of the value of the joi

How to be SURE your EGT and RPM Systems are RIGHT... Check with the B & H Instrument

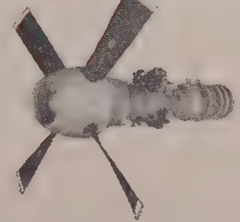
JETCAL® ANALYZER

Tests EGT System Accuracy to ±4°C at Test Temperature

(functionally, without running the engine)

Tests RPM Accuracy to 10 RPM in 10,000 RPM (±0.1%)

This NEW "J" Model JETCAL contains NEW . . . 1) Takcal, 2) "Ta'Pot" Potentiometer, 3) Ruggedized Light-Beam Galvos, 4) Test Circuits.



T-34 Turbo-Prop Engine
Pratt & Whitney Aircraft

Two of the most important factors that affect jet engine life, efficiency, and safe operation are *Exhaust Gas Temperature (EGT)* and *Engine Speed (RPM)*. Excess heat will reduce "bucket" life as much as 50% and low EGT materially reduces efficiency and thrust. Any of such conditions will make operation of the aircraft both costly and dangerous. The *JETCAL Analyzer* predetermines accuracy of the EGT and (interrelatedly) Tachometer systems and isolates errors if they exist.

The *JETCAL* is in worldwide use. Used by U. S. Navy and Air Force as well as by major aircraft and engine manufacturers. Write, wire or phone for complete information.

ANALYZES JET ENGINES 10 WAYS:

1) The JETCAL Analyzer *functionally* tests EGT thermocouple circuit of a jet aircraft or pilotless aircraft missile for error *without running the engine or disconnecting any wiring*. GUARANTEED ACCURACY is ±4°C. at engine test temperature.
2) Checks individual thermocouples "on the bench" before placement in parallel harness.
3) Checks thermocouples within the harness for continuity.
4) Checks thermocouples *and* paralleling harness for accuracy.
5) Checks resistance of the EGT circuit *without the EGT indicator*.
6) Checks insulation of the EGT circuit for shorts to ground and for shorts between leads.
7) Checks EGT Indicators (in or out of the aircraft).
8) Checks EGT system with engine removed from aircraft (in production line or overhaul shop).
9) Checks aircraft TACHOMETER system accuracy from 0 to 110% RPM with guaranteed accuracy to within ±0.1% in the operating range.
10) JETCAL Analyzer enables engine adjustment to proper relationship between engine temperature and engine RPM for maximum thrust and efficiency during engine run (Tabbing or Micing).

ALSO *functionally* checks aircraft Over-Heat Detectors and Wing Anti-Ice Systems (thermal switch and continuous wire) by using TEMPCAL Probes. Rapid heat rise... 3 minutes to 800°F! Fast cycling time of thermal switches... 4 to 5 complete cycles per minute for bench checking in production.

JETCAL

B & H INSTRUMENT CO., INC.
3479 West Vickery Blvd., Fort Worth 7, Texas

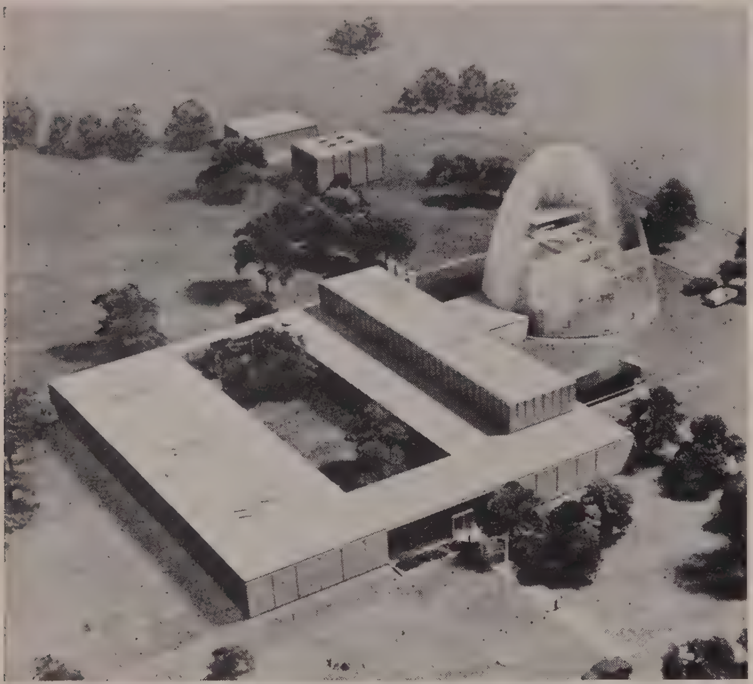
West Coast Office: 427 East Grand Avenue, El Segundo, California

B & H INSTRUMENT also makes
TAKCAL TEMPCAL

FOR MORE INFORMATION CIRCLE 5 ON PAGE 48.

effort of R & D, manufacturing and sales in terms of completed R & D projects. It also gets an idea of the return that can be anticipated from the programs for which funds are requested.

More Testing Reactors Needed



Model of the research reactor to be constructed at Plainsboro, N.J., by a combination of 10 large East Coast industrial corporations.

More reactors to test materials for atomic energy applications are urgently needed if this country is to maintain its leadership in the field. Stanley B. Roboff, manager of industrial coordination, Atomic Energy Div., Sylvania Electric Products, Inc., speaking at the Atomic Industrial Forum's annual conference said that there is but one major test reactor operating here which can provide the kind of data required to solve major materials problems. That is the AEC's materials testing reactor, which is principally used for high-priority military studies. Since Mr. Roboff's address in Chicago, a new privately owned reactor has been announced.

The future of nuclear reactor technology is riding primarily on the solution of materials problems in nuclear fules, control elements and other components, according to Roboff. He warned that the nation is faced with the immediate prospect of having far too little test space for civilian atomic needs. He called on both industry and the AEC to do everything possible to build a number of new high-flux materials testing reactors.

To be located in Plainsboro, N.J., the new private reactor will be built and operated by Industrial Reactor Laboratories, Inc., a new creation of 10 large East Coast outfits.

Forming Chemicals in Gas Discharge

The formation of new chemical compounds in a gas discharge and high-frequency field is now commercially feasible. Resulting from a 12-year development project by the Central Research Department of the Lord Manufacturing Co., the gas-phase chemical reactions are carried out in a luminous high-frequency electrical discharge and offer industry a new process technique for chemical syntheses.

The process involves the activation, formation and subsequent removal of the product in zones of controlled pressure, temperature and residence time as the reactant material is flowed through a radio frequency field of decreasing intensity.

Activated Reactant States at Lower Temperatures

The most significant aspect of this process is that it produces activated reactant states at temperatures lower than are normally involved when conventional types of activation are utilized. This means that the process is particularly suited to many syntheses involving high activation energy materials which are difficult or impossible to carry out by conventional means.

Further, since this activation energy can be supplied at low temperatures, thermally unstable products can be preserved and recovered.

Products Affected by Many Variables

At relatively low pressure and temperatures a gas under the influence of an electrical field will break down into ions, free radicals and activated molecules. Some of the activated materials will recombine to form products different from the original gas. The nature of the products formed is influenced by pressure, field strength, residence time, reactor surface material and area, temperature and discharge gap distance.

The Lord process is operable and has been studied in the range of pressures from 10 to 150mm of mercury absolute, ambient gas temperatures from —73C to 100C (in several exothermic reaction studies, this maximum temperature was increased considerably), and gas flow velocities from zero to supersonic speeds.

Lord's active interest in gas discharge work originated in 1944 as an outgrowth of experimental efforts to cure rubber dielectrically. As a research consultant on gas discharge techniques, Dr. A. L. Rouy guided the initial development work and obtained a patent on the process in 1954. Dr. Rouy is also co-inventor, along with two other staff members of improvements over his first inventions.

The Lord process is a luminous gas discharge technique presently operated at 10 to 50mm of mercury absolute pressure and 27mc. It deviates from prior art in that activation, formation and subsequent removal of the product are carried out in zones of controlled and interrelated pressure, temperature and residence time. It also involves the careful maintenance of a pre-determined optimum discharge gap distance in addition to optimum area and composition of surface material in contact with the discharge, reactants and products.

Research in the past two years has been devoted to the evaluation and control of the variables affecting product yield and power efficiency. Many factors are interrelated in their influence upon the production and recombination of disassociated molecules in a gas discharge. The conclusion reached as a result of the project is that the gas discharge process is capable of competing with other commercial chemical processes.

Wide Utilization Predicted

The gas discharge process offers much promise for the production of chemical compounds that are expensive or difficult to make by ordinary chemical means:

THORIUM

URANIUM'S INTERESTING STEPCHILD

Teddy Roosevelt was President. The age of Victorian splendor was in full swing. And incandescent gas lamps were lighting America. The heart of these glowing lamps was the gas mantle – made, for the most part, of thorium.

Lindsay was a famous name in the gas-light era, a major producer of gas mantles.

The manufacture of gas mantles calls for the impregnation of a knit fabric cone of ramie or rayon with thorium nitrate and cerous nitrate. The organic fiber is burned off, leaving a relic structure of thorium and cerium oxide which glows white hot in a gas flame.

Around 1920, gas illumination was largely supplanted by electric lighting. Demand for thorium dropped. Then came the atomic age. Thorium again became important because of its value as a reactor fuel breeder.

At the present, there are two systems in which thorium can be used as a fuel material breeder. One is the use of metal or a thorium-bismuth alloy; the other, a thorium oxide slurry reactor. Both procedures are being investigated by the AEC and private industry. It is believed that at the assumed burn-up rate of thorium oxide (one pound of ThO_2 for six megawatt hours of electrical energy) the thorium-rare earth industry is probably capable of handling domestic demands without excessive expansion. Thorium looks good as a reactor fuel for private industry because it is much more plentiful and economical than uranium.

So much for the Buck Rogers stuff . . . what's ahead for thorium, excluding the energy field? The answer to that is "plenty" and chances are it can be of immense value to you—it already is in a number of industries.

The most common thorium salts are the nitrates, oxides, fluorides and chlorides. Lindsay produces all of them in purity ranges from that required for ordinary technical use to the most critical "reactor" grade where extremely high purity is a must.

Let's see how some of these salts are being used in industry. Perhaps you'll see a potentially profitable use for them in your own operations.

$Th(NO_3)_4 \cdot 4H_2O$—Manufacture of incandescent gas mantles. A starting material for other thorium compounds and thorium metal. Nitrate is the standard commercial thorium salt.

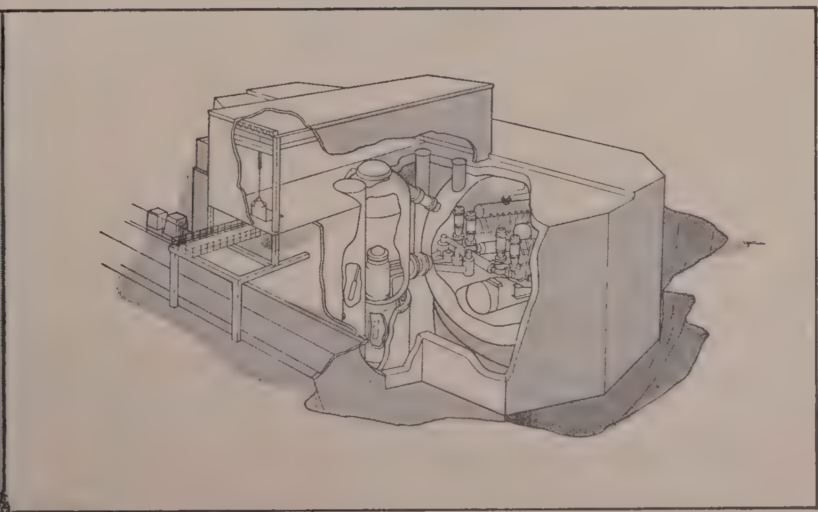
ThO_2—Thorium oxide has the highest melting point of any metallic oxide (3220°C) and has use as a refractory material. It is also used with lanthanum oxide in the production of "rare-element" optical glass for unbelievably accurate aerial camera lenses. It is a source material for making thorium metal. The AEC and several private companies are studying its use in a thorium oxide-water slurry reactor. It has some use as a catalyst.

Thorium-magnesium alloys have high strength, good creep resistance and elastic modulus values in the 600-700°F temperature range and are used in jet engine castings, supersonic air-frame constructions and satellite rockets where high temperature service is required.

Thoriated tungsten (tungsten containing 1 to 2% ThO_2) is used as a filament in electron tubes and as non-consumable electrodes in inert gas-shielded arc welding.

Lindsay is the oldest and largest producer of thorium compounds for the government and private industry but we don't make thorium metal. Naturally, since we've been in the business 54 years, we've learned a good deal about this remarkable, versatile element. Data is available to you and the counsel of our technical staff is yours for the asking.

We feel certain that thorium has enormous potentials in a variety of industries and we want to share our knowledge with you. If you think that thorium chemicals may be useful in improving one or more of your products or processes—or in the development of new products—let us be of help.



PLEASE ADDRESS INQUIRIES TO: **LINDSAY CHEMICAL COMPANY**

274 ANN STREET • WEST CHICAGO, ILLINOIS

• As a research tool, is it believed that it can produce rare compounds of exceptional purity. This would include those such as sub-halides of boron and phosphorus; high oxidation states of nitrogen and sulfur; polymeric phosphorus nitrides, halides and sulfides; carbon sub-oxides; carbon fluorine compounds; high purity tagged compounds; trapped free radicals and activated complexes.

• In the field of high energy fuel, it is the most direct route to some of the hydrides, halides and nitrides of the lighter elements—boron, lithium, aluminum, phosphorus.

• In the field of high polymers, there exists the possibility of inducing polymerization directly, or of producing free radical chain starters that can be captured and used in later polymerization steps.

• In the field of high-temperature-resistant polymers, it offers the possibility of polymerizing the necessary intermediates in the discharge. Typical intermediates would include the free radical forms of tetra-fluoro, phenyl and perfluoro ethylene oxide and tetra-fluoro-benzene.

Assessing it objectively, the gas discharge technique with its ability to produce high activation energy at low temperature indeed promises many new and interesting industrial processes.

Of the chemical syntheses investigated, the most promising one is the decomposition of ammonia (NH_3) to form hydrazine (N_2H_4). Employing concepts developed within the company, the gas discharge technique under semi-pilot plant conditions has produced hydrazine at a conversion efficiency of nearly 2% by weight. Although power efficiency is low, this conversion rate is over twice that of any other reported in the literature.

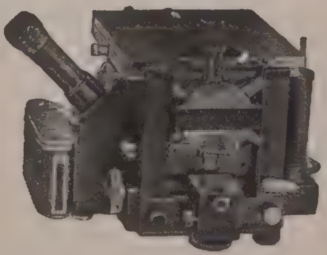
Low-temperature gas separation techniques have been successfully applied industrially to several low concentration gas phase processes. This has convinced the Lord staff that the separation of dilute hydrazine concentrations is no longer a deterrent to the commercialization of this new process.

It is believed that work now in progress will improve power efficiencies so that hydrazine production by the gas discharge process will be more than competitive with existing methods. It is felt that the production of anhydrous hydrazine by a full scale commercial plant is a realistic and practical goal.

INTERFERENCE MICROSCOPE

CARL ZEISS

MADE IN WEST GERMANY



For accurately measuring minute depths of roughness of superfinished surfaces, thicknesses of coatings, changes of surface structures due to wear, impact, stress, strain, corrosion, as well as for the studying of polished and etched metallurgical specimens.

Magnifications of 80x, 200x and 480x. Built-in Thallium and white light illuminators. Photography on 35mm film (1 x 1½-in.). Write for detailed literature and specifications on this industrial microscope.

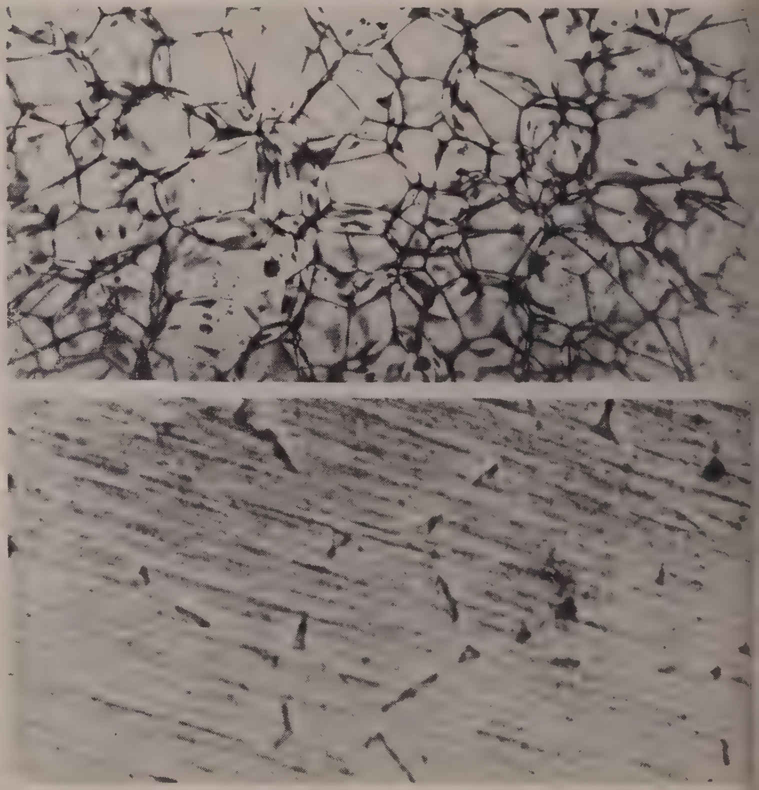
Write for free, detailed literature

Guaranteed uninterrupted repair service

CARL ZEISS, INC. 485 FIFTH AVE., NEW YORK 17, N.Y.

For more information circle 7 on p. 48

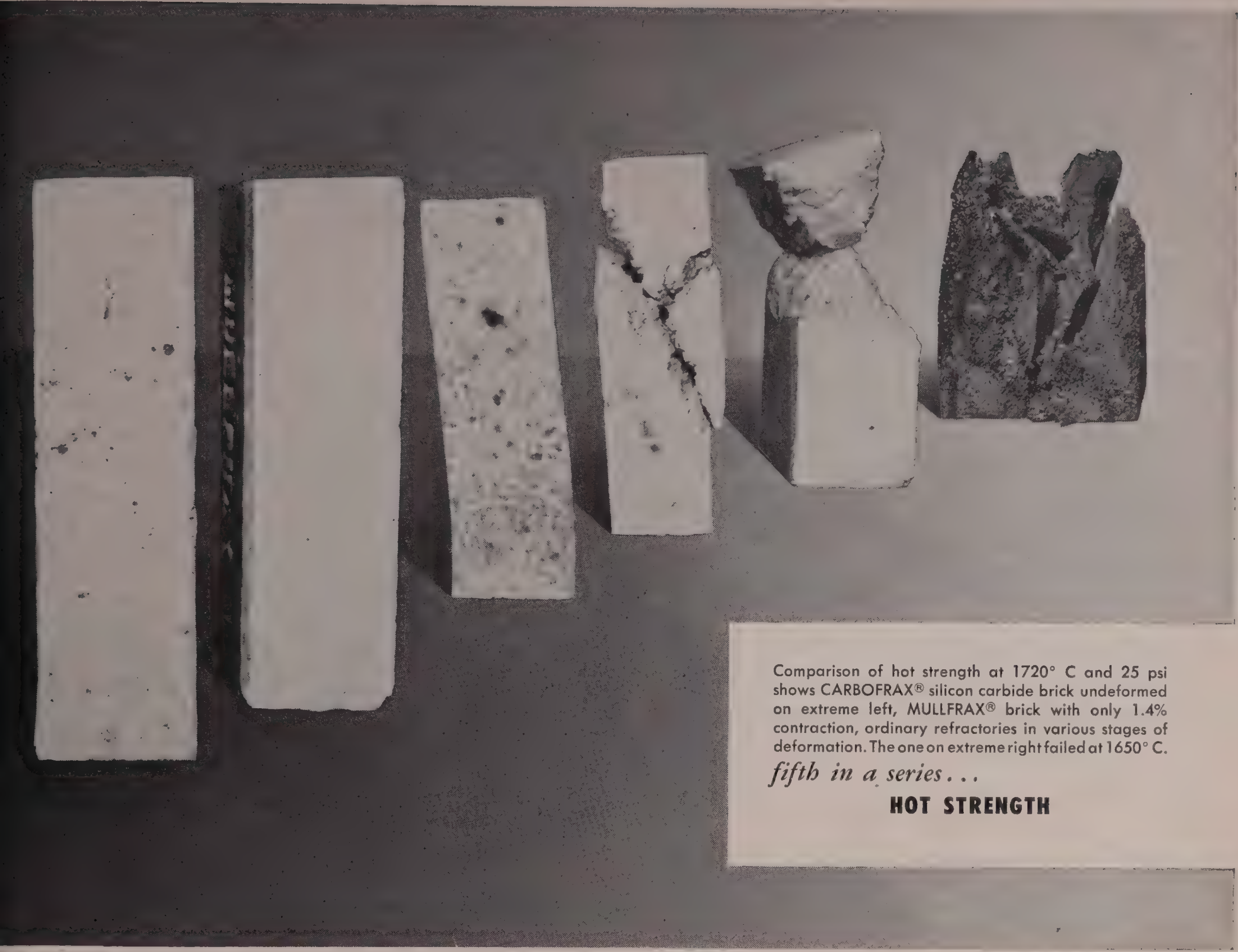
Really Looking Into "Things"



The aluminum grain in aluminum-tin bearing alloy is clearly shown in the x-ray microscope photo at the top. In the bottom photo is the same 10mm specimen viewed with an ordinary light microscope.

With the marketing of an x-ray microscope added to the introduction of x-ray television earlier this year, electronics has now taken the ball away from optics in extending man's vision (even in astronomy the radio telescope is greatly supplementing the optical telescope). Capping 60 years of research since Roentgen's discovery of x-rays, the new General Electric microscope opens exciting research possibilities in metallurgy, chemistry, biology, agriculture, medicine and criminology.

Roentgen himself was the first to try to create an x-ray microscope to look inside opaque objects, according to Fred E. Ebel of G. E.'s X-Ray Department in Milwaukee. Roentgen attempted to focus x-rays with lenses of glass, aluminum, wood and other materials. However, the refractive index of most materials for x-rays is close to unity.



Comparison of hot strength at 1720° C and 25 psi shows CARBOFRAX® silicon carbide brick undeformed on extreme left, MULLFRAX® brick with only 1.4% contraction, ordinary refractories in various stages of deformation. The one on extreme right failed at 1650° C.

fifth in a series . . .

HOT STRENGTH

Unusual Properties of Refractory Materials

Hot Strength—When load is applied to a refractory its ability to resist heat is lessened. Increasing either load or temperature, or both, often causes the refractory to fail.

As these factors are combined in most installations — large and small — hot strength of a refractory takes on new value.

The effect of temperature in combination with load is shown by specimens pictured above. Further tests provided these data: In a test under 50 psi, a MULLFRAX® electric furnace mullite brick showed no linear contraction when held at 1500°C for 100 hours. Ordinary brick contracted an average of 7.58% at 1500°C but that at only 35 psi. In another typical case complete failure (15% contraction) was experienced with a commonly-used refractory at 1350°C and a load of 25 psi.

These differences in hot strength prove this: Where refractories fail under load and temperature, Carborundum refractories have the *extra* resistance needed to avoid slumping and, thereby, to effect less downtime, lowered maintenance costs and greater output.

Hot strength may work in another way, too. It permits use of thinner section refractories, thus reducing overall load. More insulation may be used to lower heat losses.

Carborundum's magazine "Refractories" pinpoints many practical applications for these unusual products. The next issue carries a feature article on "hot strength". Send for your copy today.

CARBORUNDUM

Registered Trade Mark

VALUABLE INFORMATION FOR USERS OF:

REFRACTORIES • CASTABLE CEMENTS • POROUS PLATES AND TUBES

CATALYST SUPPORTS • OXIDE, BORIDE, NITRIDE AND CARBIDE

HIGH-TEMPERATURE MATERIALS • CERAMIC FIBER

all in the new magazine "Refractories"

—MAIL THIS COUPON TODAY—

Dept. S116, Refractories Division

The Carborundum Company, Perth Amboy, N. J.

Please send me the forthcoming issue of "Refractories".

Name__________ Title__________

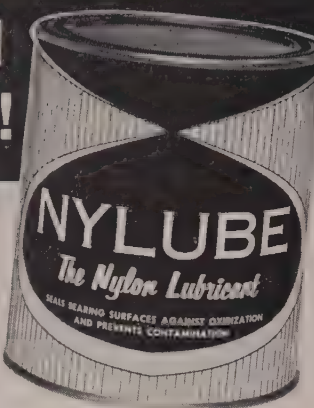
Company__________

Street__________

City__________ Zone____ State______

FOR MORE INFORMATION CIRCLE 8 ON PAGE 48

NEW NYLON LUBRICANT!



- ★ Lubricates
- ★ Prevents Oxidization
- ★ Prevents Corrosion

A remarkable new development, NYLUBE is the first lubricant specifically designed to help nylon do a better job. Its exclusive combination of lubricizing, anti-corrosion, and anti-oxidization agents seals nylon parts against contamination . . . prolongs life . . . gives quieter, smoother operation. A dry-film lubricant, NYLUBE lubricates nylon bearings and bearing surfaces without becoming gooey, sticky, runny, or messy . . . requires no wells . . . can be applied easily, to last six months and more. NYLUBE's satisfactory performance, backed by rigid in-use-tests, is guaranteed. We invite you to write for details and test samples.

SYNCO COMPANY
United Artists Building • Detroit, Michigan

FOR MORE INFORMATION CIRCLE 10 ON PAGE 48.

ENGINEERS

CONTROL SYSTEMS

Research and Development
for

AIRCRAFT NUCLEAR PROPULSION

Exceptional opportunities are now available in this General Electric Department for control systems engineers who want to be in the lead in their art. You can't be further ahead than the development of control systems for aircraft nuclear power plants. You can't find greater scope than this group charged with executing complete projects—from idea through research and development to testing.

OPENINGS EXIST AT VARIOUS LEVELS IN:

- Systems Analysis
- Servomechanisms
- Systems Applications
- Printed Circuits
- Environmental Testing
- Saturable Core Components

OPENINGS IN CINCINNATI, OHIO
AND IDAHO FALLS, IDAHO

In addition to these professional advantages, you'll enjoy the many personal benefits that go with being part of General Electric.

Send reply in confidence, stating salary requirements, to location you prefer:

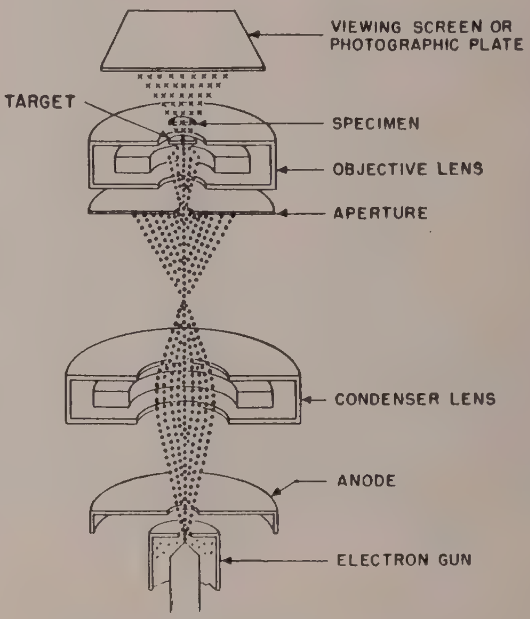
J. R. Rosselot P.O. Box 132 Cincinnati, Ohio	L. A. Munther P.O. Box 535 Idaho Falls, Idaho

GENERAL ELECTRIC

Mirrors and crystals can focus x-rays, but the loss in in-tensity is too great for purposes of magnification.

Not being able to bend x-rays practically, researcher turned elsewhere. Shadow projection looked like a logica choice. X-rays travel in straight lines and shadow projec tion depends upon the radiation of straight lines. But ef ficient shadow projection depends on a small point sourc for good resolution. Initial experiments produced an x-ray source about one-eighth inch in diameter. Heroic measure reduce the point source to about one-thousandth of an incl but even the latter is unsatisfactory for x-ray microscopy says Ebel.

General Electric solved the problem by turning to th origin of x-rays—the electrons. These can be greatly de magnified on the way to the target and as a result it is possible to generate a point source of x-rays that is less than one micron in diameter and to magnify as much as 1500 times. The construction of the microscope is shown in the accompanying cross-section drawing. The high reso



Cross-section of GE x-ray microscope.

lution that results is comparable to the best optical microscopes with greater penetration revealing structures invisible to light or electrons. The entire specimen can be in focus at once. Stereographic presentation of the image can be achieved even at highest magnification and determination of minute masses in the specimen can be made by laws of x-ray absorption.

Big Aid to Metallurgists

In metallurgy and metallography, the new microscope opens up the field of identification of inclusions, study of grain-bound precipitations, examination of microporosity, study of corrosion problems, distribution of iron in tackanites and reaction of "foreign materials" in metals.

In chemistry, according to Mr. Ebel, x-ray microscopy will aid texture studies of polomyers and effects of organic contaminent, structure study of organic oil and coatings, determination of latex films and elastimers, penetration of dyes and adhesives and study of film changes due to "weathering".

More on Acoustic Vibration

Vacuum tubes affected by rocket engine noise have also been found sensitive to sinusoidal noise of the same db level. This important correlation, which could make sonic testing of tubes simpler, was discovered by Dr. Werner Fricke of Bell Aircraft in Buffalo. Single frequency noise is simpler and cheaper to produce than rocket noise for acoustic vibration test purposes.

The tubes, 20 *5814*'s, were subjected to 150db sound in the illustrated Bell "noisemaker", a long resonant cylinder. This is the sound level recorded in the aft compartment of a Bell missile propelled by a rocket developing 12,000 pounds of thrust. Dr. Fricke is also the first engineer to have tested transistors for their ability to withstand acoustic vibration (see RESEARCH & ENGINEERING, Sept., 1956, "New Sound Barrier: Obstacle and Opportunity", p. 20). He revealed this latest development at the recent conference on Tube Techniques in New York, sponsored by the Advisory Group on Electron Tubes.

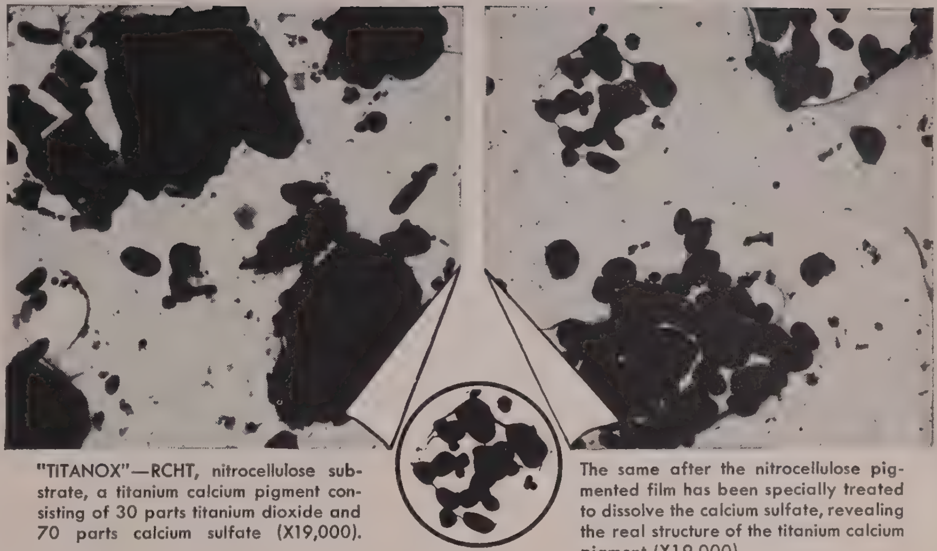
The sound source used by Dr. Fricke only delivers one watt of acoustic power, but this is sufficient to produce sound levels up to 160db in the tube.

Sonic Testing Goals

Although none of the standards organization have prepared specifications for sonic testing, Wright Air Development Center has published some future goals for such tests. The three goals published, known respectively as grades e, f and g are as follows: 150 to 4800 cycles per second bandwidth at 150db; 150 to 9600 cycles per second at 165db; and 150 to 19,200 cycles per second at 165db. The goals are listed in a document known as R&D Exhibit WCRE 56-1B titled "Environmental Design Requirements and Test Methods for Electronic Component Parts for Use in Airborne Equipment". It can be obtained from Mr. Yale Jacobs, Chief, Electro Mechanical Branch, Electronic Components Laboratory, Directorate of Research, WADC.

PHOTO COURTESY OF JET PROPULSION

One of the Bell noisemakers, a long resonant tube with associated measuring instruments and noise source.



"TITANOX"—RCHT, nitrocellulose substrate, a titanium calcium pigment consisting of 30 parts titanium dioxide and 70 parts calcium sulfate (X19,000).

The same after the nitrocellulose pigmented film has been specially treated to dissolve the calcium sulfate, revealing the real structure of the titanium calcium pigment (X19,000).

They Saw the Real Structure of Titanium Calcium Pigment for First Time!

RCA Electron Microscope at National Lead Company Reveals Make-up of this Useful Material

Development of the Electron Microscope over the years to the present high level of efficiency has permitted extended exploration in the field of pigment technology. According to W. R. Lasko of the Research Laboratory of National Lead Company, Titanium Division, South Amboy, N. J., "The RCA Electron Microscope has revealed for the first time the real structure of titanium calcium pigment.

"We found that the particles of titanium dioxide in this widely useful pigment are coalesced around the surface of the calcium sulfate. Thus, identification of the individual components is possible. Size and shape of the calcium sulfate as well as of the titanium dioxide can readily be observed. The titanium dioxide industry has been immeasurably aided by the electron microscope."

RADIO CORPORATION of AMERICA

Whether your field of micrographic interest lies in metals and pigments, or in products of any one of the dozen or more industries now using the RCA Electron Microscope, your studies, too, can no doubt be immeasurably aided by this magnificent new research tool. For further information, write to Dept. L-281, Building 15-1, Radio Corporation of America, Camden, N. J. In Canada: RCA VICTOR Company Limited, Montreal.

Installation Supervision is supplied, and contract service by RCA Service Company is available with the Electron Microscope if desired.

FOR MORE INFORMATION CIRCLE 11 ON PAGE 48.

LIQUID ENGINE DIVISION

In piloted aircraft, missiles, and upper-atmosphere research vehicles, Aerojet-General liquid-propellant rockets have proven unexcelled for assisted takeoff, superperformance, and as prime power-plants.

Whether your interest lies in Vanguard or valves, Aerojet-General offers a variety of challenging assignments for:

Mechanical Engineers
Electronic Engineers
Chemical Engineers
Electrical Engineers
Aeronautical Engineers
Civil Engineers
Metallurgists
Chemists
Physicists
Mathematicians
Technical Editors

Aerojet-General CORPORATION
A Subsidiary of The General Tire & Rubber Company — THE GENERAL TIRE — AZUSA, CALIFORNIA SACRAMENTO, CALIFORNIA

Write: Director of Scientific and Engineering Personnel, Box 296A3, Azusa, Calif. or Box 1947A3, Sacramento, Cal.

Letters

A Big Help

Little Neck, New York

I would like to express my appreciation of your many interesting and informative articles. Your articles on Management are very thought provoking. Some of these articles on Management of a research team are helpful and inspiring. Technical articles, such as those on sources, solar energy and ceramics were interesting reading which could prove useful. In fact, the recent article you presented on "Government R/D Contracts: Pitfalls & Procedures" by Max Hoberman (Editor's Note: Sept., 1956, pp 26-30), has apparently proven so useful to one of my associates that he has not returned it. I have mentioned this article to the Chief Engineer of Hazeltine Research Corporation, and he is very interested in seeing it.

WALTER C. ESPENLAUB
Hazeltine Electronics Corporation

Humanities Weak

Rolla, Missouri

Thank you for accenting the results of the ASEE study by advocating "Broader Vistas for Engineers" in the July issue. It is an unfortunate reality that the humanity departments of our engineering colleges are inadequately staffed. This situation all too frequently engenders in the engineering student a healthy disrespect for anything that smacks of the "liberal arts."

Being familiar with the professional competence of technical instructors, the student is quick to sense the attitude of indifference attendant on unqualified or uninspired direction in the social sciences. He accepts this attitude as the legitimate reaction of the "scientist" to "impractical culture." His acceptance is further confirmed by the action of a few college administrators with technical backgrounds who consistently discuss the importance of the humanities with tongue in cheek.

In the problem of "protracted vistas," I suggest that the presence of technically trained administrators in engineering education is suspect. An administrator possessing technical education exclusively is peculiarly unsuited to his work. Administration must necessarily require adeptness and flexibility in the field of human relations. A technical education is not designed to develop these skills.

Much experienced engineering ability is being sidetracked into administrative duties, duties which could be discharged more effectively by persons with broader educational backgrounds. When these positions are filled by educators rather than by engineers, when engineering education is administered by liberal men rather than by technical men, then we can expect the study of the humanities to assume some semblance of its intrinsic dignity.

CHARLES G. EDWARDS
Research Fellow
Missouri School of Mines

The Worm Turns

Peoria, Illinois

Our attention has been invited to an article which appeared on page 12 of your July 1956 issue. It related generally to drawbar horsepower of track-type tractors, and in the fifth paragraph your referred, also generally, to this type of machine as being a "caterpillar tractor."

This letter is written to inform you that "Caterpillar" is a trademark granted exclusively to our Company in describing this type of product. Your use was probably inadvertent, and we would suggest that in the future, you use "crawler" or "track-type" in describing products of this kind, not of our manufacture.

The article was most interesting.

BURT POWELL
Advertising Manager
Caterpillar Tractor Co.

We Bow Our Heads—

Haverhill, Mass.

As you have been told by many correspondents, your magazine has a very lively and interested audience; also, a very critical audience. May I suggest that, for best success in your chosen market, much more careful editorial work is essential?

As an example, look at the feature article, *Research and Development for Profit*, in the June, 1956, Issue. My one reading uncovered the following items: P. 18, first column, line 11: "million" presumably should be "billion", since the table on P. 20 shows over one billion for corporate expenditures alone. P. 22, second column, next to last line: "Is" should be "are". P. 24, second column, line 4: the word "percent" should be omitted. P. 25, second column, 15 lines from bottom: "three to four" percent should read something like "six to eight" percent. This can be checked from the three or four lines above—"General Electric reports that their 1955 R & D expenditures were over three times the average for manufacturing industries"—"The average R & D expenditure for all manufacturing industries is believed to be between 2.0 and 2.5 percent of gross sales." If this is not convincing, see also P. 20, second column, 10 lines from bottom: "—General Electric which has, however, reported that its R & D costs in 1955 were well above the estimated—average of six percent of sales."

R. R. WHIPPLE
Assistant Superintendent
Manufacturing Engineering
WESTERN ELECTRIC COMPANY

No Cheers

New York, N. Y.

With respect to the letter headed "Cavemen with Gadgets", in April 1956 issue of RESEARCH & ENGINEERING, may I suggest that the article (sic) would have merit if a logical development would ensue.

A good dissertation requires an introduction to the problem, a step by step discussion, with some examples thrown in to support the ideas presented, and concrete conclusions.

If the author intended a discussion on basic entities, say "material versus spiritual values" he should so state and eliminate all examples which were intended for basic thoughts.

In my opinion, the letter deserves some criticism rather than praise as typified by letter on page 6 Vol. 11 No. 7 of RESEARCH & ENGINEERING titled "Engineer's Wife Talks Up".

EARL P. PURPURA

s'Gravesande's Stoomwagen

s'Gravesande's Steam Reaction Car

In 1721 Jacob Willem s'Gravesande of Delft, stimulated by the recently enunciated Third Law of Motion, astounded the Royal Society by constructing a practical steam reaction car. The vehicle actually moved several times its own length, a distance of about two meters.

In 1956 the goal is no longer meters, but hundreds, and even thousands, of miles. Aerojet-General Corporation, leader in American rocket propulsion for more than a decade, is proud to participate in man's first assault on the frontiers of outer space—Project Vanguard.

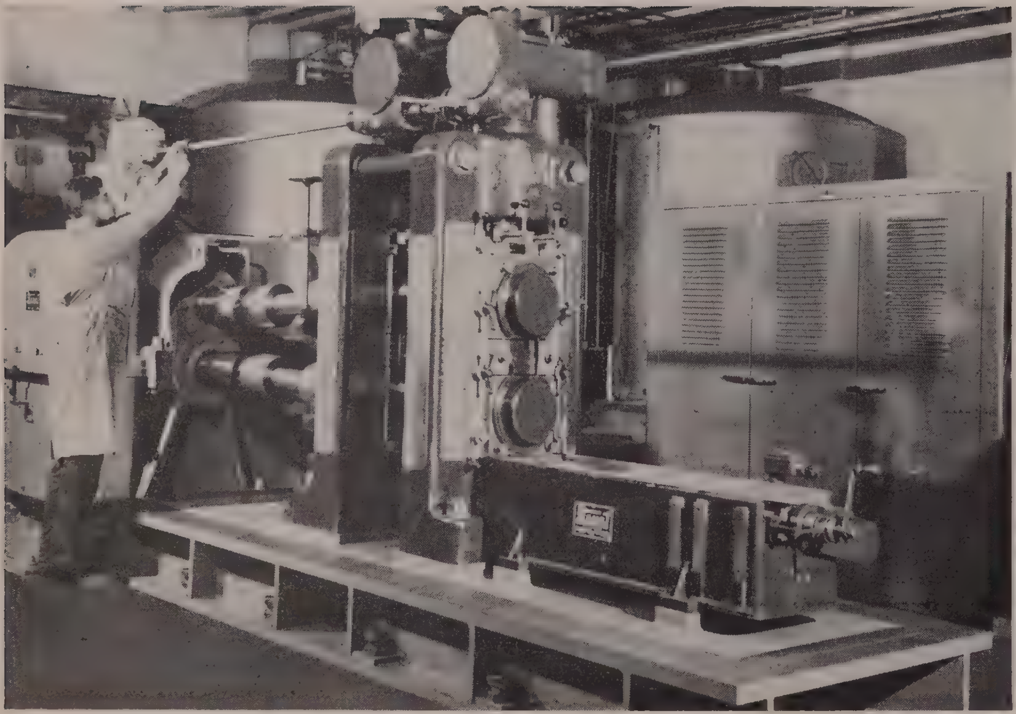
Aerojet-General CORPORATION

A Subsidiary of
The General Tire & Rubber Company

AZUSA, CALIFORNIA
SACRAMENTO, CALIFORNIA

Aerojet-General invites scientists and engineers—men of imagination and vision—to join the attack on the most significant research, development and production problems of our time.

prototypes



Remote-Control Rolling Mill

Designed to process radioactive materials, this rolling mill will operate in an air tight enclosure in a helium atmosphere. The operator will control the machine remotely through arm-length gloves.

Developer: Stanat Manufacturing Company, Inc., Long Island City, N.Y.

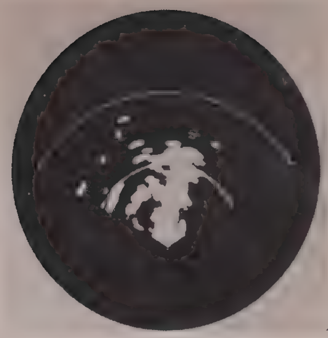
For more data circle 16

Big Whistle

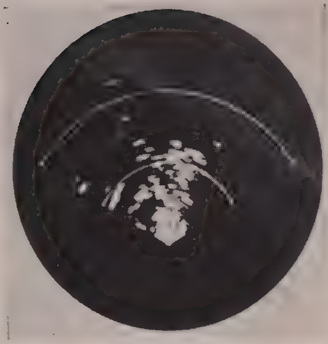
There are no moving parts in this highly efficient ultrasonic whistle. It produces high-intensity sound in the range from 4 to 40kc. Developed by Dr. Raymond Boucher of France, the whistle can be operated in either gas or liquids at temperatures to 700°C. It can be driven by an air compressor or steam generator.

M'f'g.: Gulton Industries Inc., 212 Durham Ave., Metuchen, N.J.

For more data circle 17 on p. 48



Without Amplifier



With Amplifier

Housekeeper for Radar

A newly developed circuit for radar receivers removes "clutter" as shown in these photos. For use in both ships and planes, the improvement strengthens weaker "pips" without bolstering the strong images. The seven-tube circuit is called the Clutter-Operated Anti-Clutter Amplifier.

Developer: Allen B. DuMont Laboratories, Inc., Clifton, N.J.

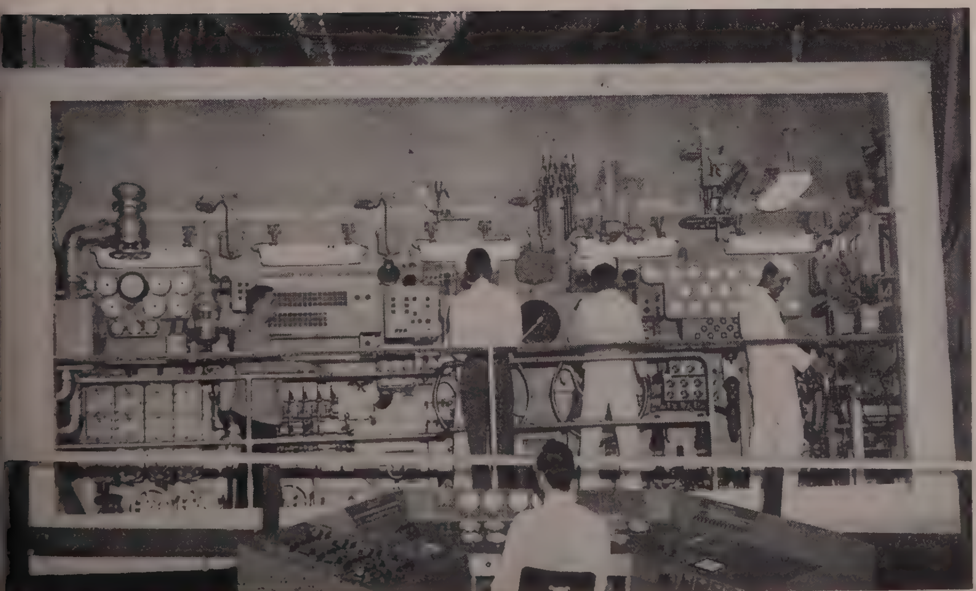
For more data circle 18

Holds 64,000,000 Characters

This is one of 200 "pages" in the RAM Random Access Memory. It is made up of standard 5/8" 8-channel magnetic tape strung vertically on racks. Access to one of the 64 million 8-bit stored characters is a matter of less than a second. Coded data initiates lifting one of the pages against the read-record magnetic leads.

Developer: Potter Instrument Company, Inc., 115 Cutter Mill Rd., Great Neck, N.Y.

For more data circle 19 on p. 48



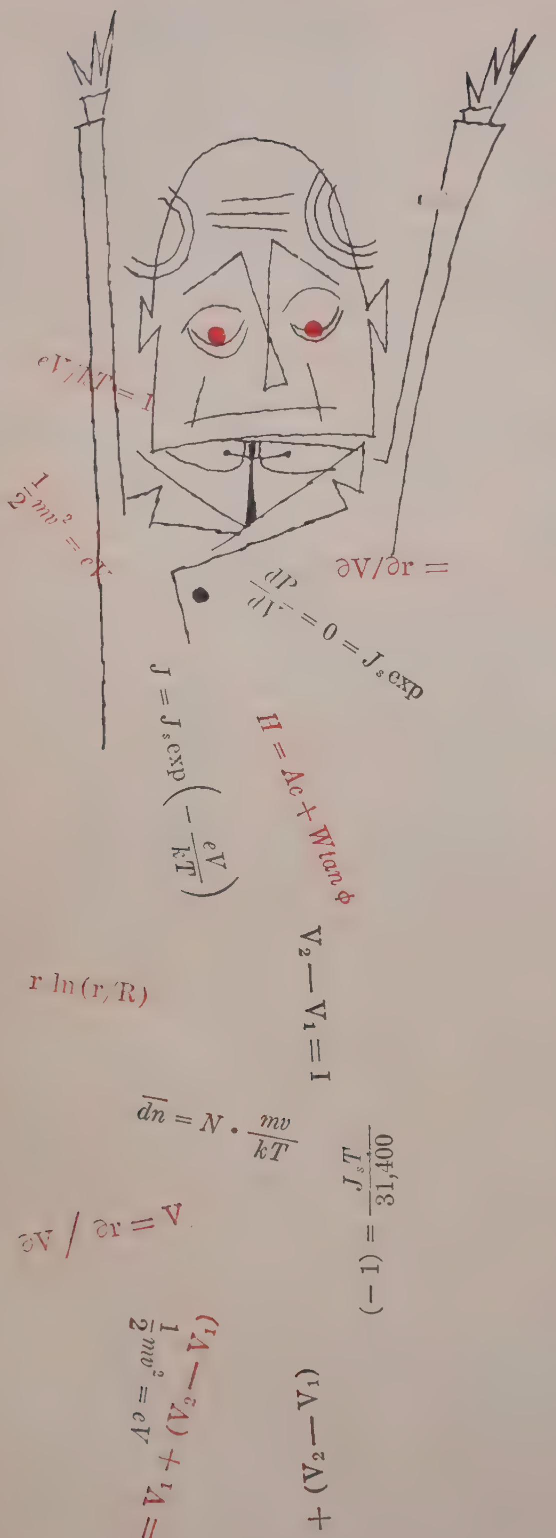
Simulated Submarine

The control characteristics of all USN subs now in service can be duplicated on this simulator. An exact replica of a control room, it trains helmsmen and planesmen. Operator at console in foreground feeds ship and sea data into a control computer built by Mid-Century Instrumatic Corporation of New York.

Developer: Electric Boat Div., General Dynamics Corp., Groton, Conn.

THE CONCEPTUAL OBSTACLE COURSE

Alfrred M. Freudenthal



Before allowing a project to start, the technical manager must make sure that his engineers and researchers have not fallen into any dangerous traps in formulating the problem. Here's how to recognize four of the most serious ones—the possible results of unclear thinking.

The truly understandable, well considered and relatively complete formulation of a problem represents the principal and most important part of any research, basic or applied. Although the assumption that research workers and design engineers will agree with this statement would appear to make its discussion unnecessary, anybody who has first-hand experience with R/D organization and direction will know that no other principle is as frequently and as consistently violated. It is obvious that this part of the problem should be the technical director's and the professional's most serious preoccupation. No amount of mechanization, of electronic devices, of "powerful methods" of mathematical analysis can, at this stage of the research and development work, replace or even assist the human brain in recognizing and formulating the problem, and avoiding dangerous traps. The project is frequently started before the problem is completely formulated. The problem that is formulated hastily in order to "get the job going" is not always the problem that should, in fact, be studied.

It is, in general, easier to find people with a faculty for analytical thinking than those who can think both analytically and synthetically, who can not only analyze a given problem, but formulate a problem in all its aspects. It is very disturbing that almost anybody realizes that a good golfer is the result of training and continuous practice, although it is quite clear that some people are more easily trained than others, while we quite seriously expect a man to think whose mind has not been systematically trained to do so—who has been accustomed to acquire information rather than knowledge, who expects to be taught rather than to be given the opportunity to learn, who likes to answer "true" or "false" questions and loves "survey courses"—and thus expect this man to do effective research himself, or to become an R/D director.

It is quite likely that such a man can be trained to operate an electronic computer, to master certain techniques of mathematical analysis, to build a rather complicated piece of measuring apparatus if given specific instructions concerning the required performance. But before the electronic computer can be asked to supply the answer to a question, before the analysis can be applied, before the required performance of the apparatus can be specified the problem has to be formulated understandably, unequivocally, and in all its aspects, considering all possible significant variables. At this stage the human mind, the individual ability is irreplaceable. Only the human mind can answer the question: What is the problem . . . really? And unless this question is correctly answered, money and effort will be wasted in a research project the results of which will have little bearing on the actual problem. In answering the question and in formulating the problem four traps must be carefully avoided.

The Semantic Trap—I

Voltaire very aptly defined the semantic trap by saying, "When people talk about a thing they do not know, they use words they do not understand." We are trapped by the words we use into accepting analogies, comparisons, definitions, that have little relation to the problem; we give a new name to a phenomenon and think we have "explained" it; we confuse words with things for which they stand. For example, the behavior and evaluation of properties of materials is full of semantic confusion. We call "ultimate tensile strength" of a metal an experimental value which is neither ultimate nor a strength, but is obtained by dividing a force producing instability of the deformation by a no longer existing initial cross-section. Thus, if the answer to the question: "What is the strength of this particular material?" is given by specifying its ultimate tensile strength, not much has been said that could be considered a meaningful answer. Not only does the metal we are concerned with have different properties at the end of the test than at its start, so that the "strength" figure can only refer to the metal as changed by the test, which may bear little

resemblance to what we intend to establish, particularly since the testing conditions only very seldom resemble the anticipated service conditions, but the figure itself has very little to do with strength, representing only a characteristic instability phenomenon of the tension test as such. Still, we design structures using the "ultimate tensile strength" as a criterion, we evaluate metals on the basis of this figure.

Similarly, when we deal with stress-strain relations, it is very frequently forgotten that the shape of this relation is as much, if not more, dependent on our definition of strain than on the actual performance of the material. In engineering terminology a force-deformation diagram (the so-called "engineering stress-strain relation") is usually referred to as a stress-strain diagram. Moreover, strain is frequently defined rather arbitrarily, for instance either as $E_1 = \Delta\varepsilon/\varepsilon_0$ or as $E_2 = \Delta\varepsilon/\varepsilon$, where $\Delta\varepsilon$ denotes the elongation, ε_0 the initial and ε the final length. Since therefore $E_2 = (\varepsilon - \varepsilon_0)/\varepsilon = (1 - \varepsilon_0/\varepsilon)$, the strain-measure E_1, goes to infinity as increases towards infinity, while the strain-measure E_2 goes to unity. Thus even for $\Delta\varepsilon = 0.2\varepsilon_0$ the two strain measures give the alternative values $E_1 = 0.20$ and $E_2 = 0.167$; for larger values the discrepancy becomes very serious, since the scale from $E_1 = 0.5$ to infinity is projected or the scale from $E_2 = 0.33$ to $E_2 = 1.0$, producing the characteristic S-shape of the $(\sigma - E_2)$-relation. Quite a number of papers have been based on attempts to extrapolate the apparent straight-line part of this relation in the vicinity of the inflexion point (every S-shaped curve is very nearly straight in the vicinity of its inflexion point) toward $E_2 = 1.0$, to determine a "true cohesive strength", without realizing that it is the particular strain-definition which produces the S-shape and which therefore has nothing to do with the performance of the material, and can certainly not be extrapolated by a straight line. It is obvious that only a fictitious "true cohesive strength" can result from such extrapolation.

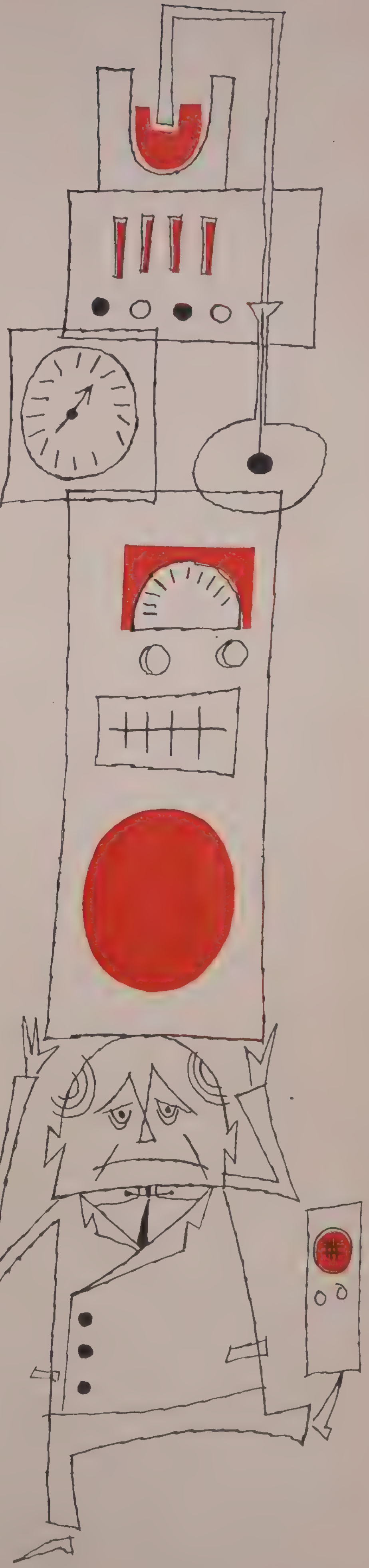
Using Figures No Cure

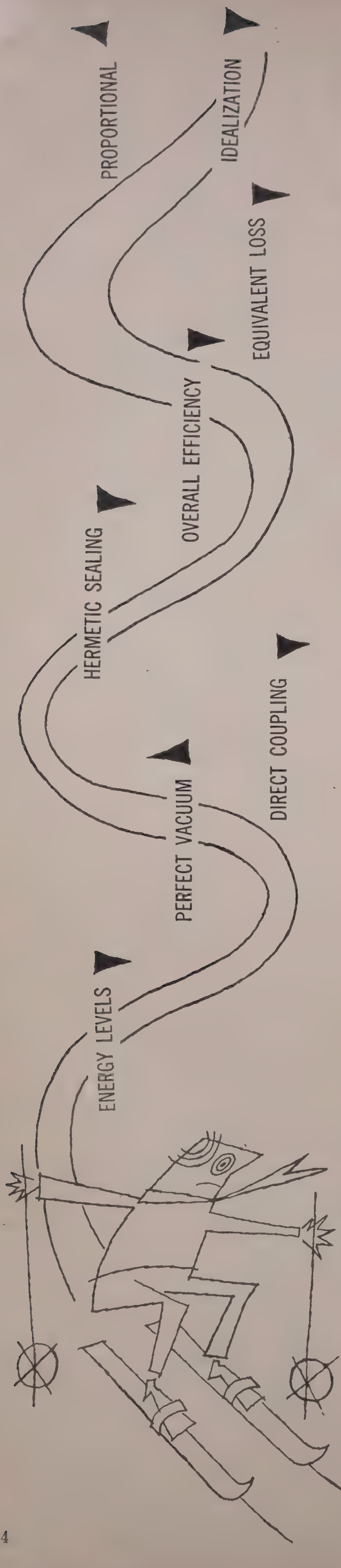
We assume frequently that the semantic trap is avoided by using figures rather than words. This is not so. If you are dealing with mathematics, clear statement can be made in terms of figures, in terms of symbols. If you are dealing with physics, however, the rigorous statement cannot be more rigorous in a physical sense than the meaning of the figures. You can obviously have a rigorous statement relating two variables X and Y, but the concept of a function X of Y is physically meaningless unless the physical quantity for which X stands and the physical quantity for which Y stands are clearly defined. The fallacy is to assume that the use of mathematics automatically saves us from the necessity of thinking and of specifying what our symbols physically **mean.**

The Analytical Trap—II

Certain idealizations in assumptions produce certain analytical procedures. We are quite familiar with the fact that the idealization of the real engineering material by an elastic continuum has made most of our stress analysis possible. We assume the existence of a linear system; the linear system produces a linear differential equation which can be solved. Therefore we have established a means of solving a very large group of problems. These solutions, however, cannot be more rigorous than the underlying assumptions. We can hardly expect to solve problems concerning a material which by nature is not elastic, by solving the differential equations of the elastic continuum. Again this statement looks commonplace. However, consider as an example recent problems involving the mechanical design of nuclear reactors. The Atomic Energy Commission and its contractors have been publishing a large number of papers summarizing and reporting investigations on thermal stresses at elevated temperatures. While these investigations are by themselves very important, everybody knows that at high temperatures there is a phenomenon called "creep", that is a time-dependent, progressive and irrecoverable deformation. The existence of this type of deformation fundamentally contradicts our assumption of linear elasticity of the system. Still, in most cases we use methods of elastic analysis to establish the stresses in parts operating at elevated temperatures to compute the inelastic component of the deformation on the basis of these elastic stresses. However absurd it may seem, this is standard procedure. The reason for this procedure is the fact that the solution of the inelastic thermal stress problem is very cumbersome. Therefore, it is obviously easier to take the existing procedure of elastic analysis which gives relatively simple expressions, although these expressions are in many cases completely meaningless; their use in design will necessarily produce structures that are either wasteful or unsafe. This situation arises from the fact that the comfort derived from the existence of relatively simple and effective methods of mathematical analysis appears to reinforce the general disinclination of many designers to think unconventional problems through and to consider the actual performance of the materials they are dealing with.

Although they fully recognize the fact that the material is not elastic since they are designing the structure for creep, they stick to the use of the elastic stress-analysis because the methods have been developed and it would take a major effort of rethinking their problem to find an adequate alternative procedure. The point is that the solution of a problem is rigorous not only mathematically, but physically, only if and as long as the assumptions are





A past contributor to RESEARCH & ENGINEERING ("The Formulation of Problems in Research", July, 1956), Dr. Freudenthal is presently Professor of Civil Engineering, Columbia University.

valid. Although everybody will say that this is quite obvious, if you look at the actual practice, you will have your doubts about the application of this principle.

The Equipment Trap—III

An R & D problem is very frequently formulated on the basis of the existing equipment by the aid of which it is hoped to find a solution. Absurd research programs are justified on the basis of the statement: "Let's do it because we have the machines". If you look around in many R & D organizations, including universities, busy formulating research problems to submit to sponsors, you will find that considerations frequently start from the machines that are available; the problem is then formulated to fit the particular machines. We have to recognize the fact that the more highly mechanized our work, the more elaborately equipped our laboratories with commercial equipment, the worse off we will be in solving fundamental problems. The reason that the British are quite successful in solving such problems, which we then take over from them for development, is that they usually have little money to spare for construction or purchase of elaborate equipment. Therefore, a British research worker may have to spend six months thinking about the equipment before he can actually afford to construct it; the chances are that such apparatus will be particularly suited to the problem, and the answers obtained with its help therefore quite significant. But if you have a few hundred thousand dollars to spend on equipment in a hurry, you will, after having bought the apparatus, be tied hand and foot. From now on it is only on such apparatus that you will be able to work. If you later try to convince your management that they should spend more money after having spent so much, they will want to know what you did with the money in the first place.

Fundamental Research Very Susceptible

There is, in fact, a very real danger in buying commercial equipment if you are interested in fundamental research. Only if your "research" problem is a simple conventional one, such as comparison in a more or less arbitrary manner or classification, are such machines sufficient. For basic research, however, they are of little use. In most fields of research the filling of a laboratory with commercial equipment will seriously interfere with effective planning of research work, since every research problem will necessarily be considered in the light of the available facilities. The chances are that when a larger piece of research apparatus has become a sales item, it is no longer particularly useful for fundamental research, since it would never have become a sales item unless it can be used by a relatively large number of people in a type of work that has necessarily become standardized. This consideration does obviously not apply to small components that can be used to build up various forms of experimental apparatus, but only to complete experimental or testing devices.

Fatigue research is an illustrative example of the above point. It is rather easy to construct a machine that applies the same load cycle a hundred or a hundred million times, and then devise tests in which the fatigue lives of certain specimens of a certain metal are determined by such a machine. Unfortunately, the results of such tests have very little bearing on the fatigue performance of the structure under randomly varying loads as, for instance, in the flight of an airplane or in the travel of an automobile the rear axle of which, as you very well know, is not subject to the same amplitude of stress all the time. Since about 1878, when a German professor by the name of Woehler started systematic fatigue tests under constant load cycles, very little has changed. During the war, for instance, the Battelle Memorial Institute published several volumes of fatigue data. There is very little you can do with them, if your interest is in fatigue design. Similar tests, however, are still going on everywhere simply because no better equipment is available. It is only now that we are trying to design fatigue testing procedures which represent, to some extent, the service performance of the structure we want to design. Such procedures, however, require quite elaborate testing apparatus. Thus fatigue research has in fact been hampered by the early development of too simple fatigue machines.

The Statistical Trap—IV

At present everybody agrees that experiments should be statistically planned and statistically evaluated. Nevertheless, very few people try to specify what kind of statistics should be used for the investigation of a particular problem. Speaking during the last British elections, Sir Winston Churchill, as is his habit, coined a very apt phrase. He said, "On the curb and in elections, it is margins that count and not averages". The same is true in design. It

is margins that count in design and not averages. Most of our statistics, however, are based on averages and deviations from averages, assumed to be normal. The existence of a normal distribution is based on the theory of averages. The statistician is fascinated by averages, the designer can do very little with them. We know very well that the statistical populations, particularly those we encounter in materials research, are very far from normal. It is only when we use averages of groups of samples that we get back to the normal distribution, provided we have enough data, which we may have in quality control, but almost never have in research. The designer, however, is only interested in extreme values. He wants to know the lowest possible resistance value with some degree of confidence, which cannot be obtained from the non-existent normal distribution. He can never be satisfied if the figure involves a 50-50 chance of being exceeded or not being attained, but this is what we are getting in most of our experiments and this is the only way in which our present statistics can be applied to small samples out of a non-normal population. What we have to employ is a new statistics for this particular purpose. The statistics of averages has its uses in quality control work, but it is more or less useless for many other important purposes, most of them arising in design and research. We need a new type of statistics in which it is the form of the distribution function, the tail of the distribution function that is important, not the averages. However, if you open any one of the many recent books on "experimental design", meaning statistical design of experiments, all you get is conclusions and rules based on our old friend, the Normal distribution. Poincare has said that the mathematicians accept the distribution because they think it is a physical reality, while physicists use it because they assume it to be a mathematical law.

In More Than One Trap at the Same Time

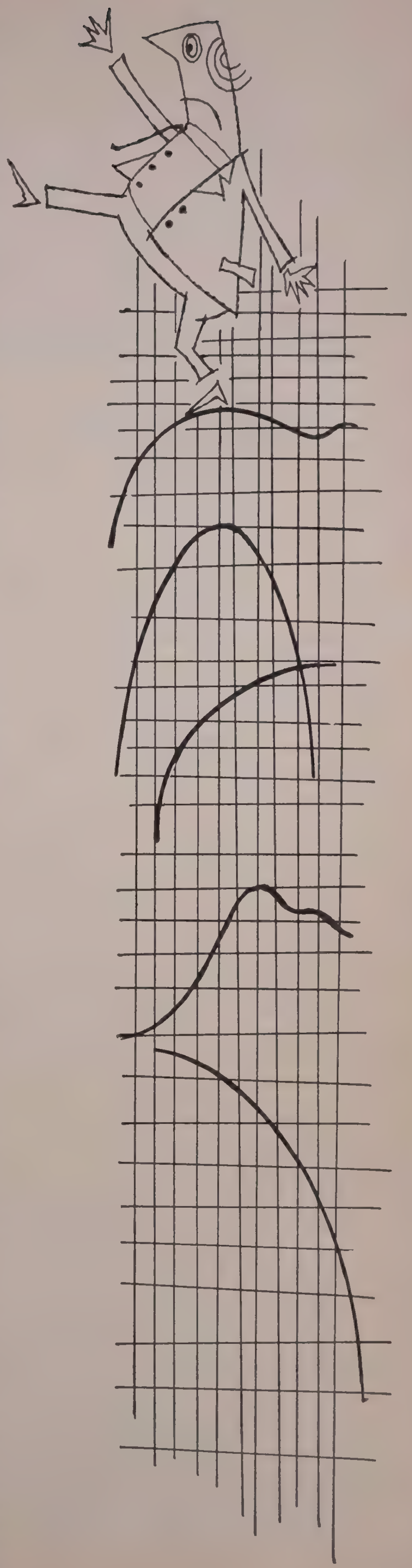
That it is very easy to fall into any one or into a number of traps simultaneously is easily seen when considering the general level of research in materials evaluation, for example. We have progressed very far in being able to produce materials to certain specifications; to establish such specifications in terms of performance, however, it is a much more difficult problem. How inadequately such problems are handled can be illustrated on the sample of the development of a "high strength" structural aluminum alloy for air-frames, the so-called 75S-T. The problem has been stated as the production of a metal with increased yield stress; simultaneously the fatigue life has been reduced by about two orders of magnitude.

Safety and carrying capacity of structures and parts provides another field of wide confusion between the real problem and the investigated problem. Required are load statistics, strength statistics and their correlation in terms of extremes, in order to rationally formulate the safety problem. The engineering profession has, in general, not even grasped the fact that such a problem can be formulated on a rational basis. We design bridges, we design machines, we design aircraft. And we always talk about the safety of the designed structure. However, if you try to get an engineer—civil, mechanical, metallurgical, (the electrical engineer doesn't know enough about it to discuss it)—to try to tell you what is the structural safety of a particular structure he has designed, you will get as many replies as you have asked people. And if you investigate the research work in the field you will find that in the formulation of most of it, not a single of the four traps has been avoided: the semantics is fuzzy, the analysis has no basis in reality, the testing procedures are irrelevant to the problem, and the statistical assumptions are unjustified. Still, it is on the basis of such research that millions are spent in designing "safe" structures.

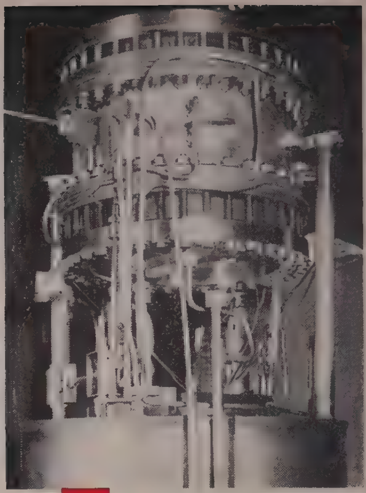
Plenty of Problem Solvers

Similar examples in the various fields of research activity can be easily uncovered, and show the importance of the correct formulation of the problem before trying to solve it. We are able to solve quite a number of given problems. We have the manpower well trained in the solution of problems; and our progress in problem solution is amazing. Our main difficulty is in finding people trained in the *formulation* of problems, everywhere. The amount of money wasted on the solution of vague or inadequately formulated problems in research is spectacular.

If in this respect we ask, "What is the problem, really?" our answer can only be: the development of young people with minds trained in critical, independent thinking. Such young research workers, by the way, will also be the best answer to Professor Zadeh's fear of the domination of the machine, even by a political one. It is only the man who loves standards and cliches who will be quite easily dominated by machines. The man who wants to formulate all his problems independently and who has been accustomed to answer questions only after their real meaning has been clearly defined, is also the best guarantee of improvement of our research, both industrial and basic. We will have to give some urgent thought, (with apologies to our teachers colleges) to the fact that the "well integrated personality" toward which, unfortunately, most of our education is directed, is the least likely to be this type of man. "Integration" is probably an acceptable by-product of an education, if you can get it without neglecting its principal aspects: education to think clearly and education to form a sense of values compatible with such thought. END



New Highs for Low Temperature Engineering



University of California 10 inch diameter liquid hydrogen bubble chamber.

NEW METHODS FOR GAS LIQUEFACTION

NEW PROCESSES FOR ISOTOPE DISTILLATION

NEW TOOLS FOR BASIC STUDIES

NEW INDUSTRIAL APPLICATIONS

Last August RESEARCH & ENGINEERING reported on a High Temperature Symposium held earlier this year at Berkeley, California. Now we have a report from the other end of the temperature scale: the 1956 National Cryogenic Engineering Conference. Held last September 5 to 7 on the doorstep of the Rockies at the Boulder, Colorado laboratories of the National Bureau of Standards, the meeting was the second national conference of this type.

Sponsored by the NBS Cryogenic Engineering Laboratory and most of the leading industrial firms currently active in this rapidly expanding field, the conference attracted more than 400 delegates who listened to about 50 papers. They covered a variety of topics associated with the production and use of liquefied gases such as hydrogen, nitrogen, oxygen, helium and the very low temperatures which these liquids nourish—temperatures which in general cover only the lower half of the 300 centigrade degree interval from absolute zero to ordinary room temperature.

The word "cryogenic", comes from ancient Greek and means "the creation of icy cold." The cryogenic engineer, however, works with temperatures 100's of degrees colder than that of ordinary ice; in fact down to near absolute zero.

NBS's little booklet on its cryogenic engineering laboratory reports that in the early days of low-temperature research the principal advances were made by experimenters whose goal was liquefaction of all known gases and determination of their physical properties. This era culminated in 1908 when H. Kammerlingh Onnes of the University of Leiden, succeeded in liquefying helium, the most volatile of all materials. Onnes' accomplishment initiated a completely new field of physical research. The phenomenon of superconductivity, "superfluid" helium II, and properties of paramagnetic salts which provide means for approaching absolute zero depend upon liquid helium as the refrigerant and are still the subjects of important basic research. In the meantime, even before the liquefaction of helium, the cryogenic engineer entered the picture when many gases of industrial importance began to be economically separated and purified by low temperature distillation.

Today, reports NBS's bulletin, nearly all of the oxygen and hydrogen of commerce, both in gaseous and liquid states, all of the neon for the brilliant advertising signs, the argon and krypton for filling incandescent lamps, and the helium for shielded arc welding are produced by low-temperature processes. The accomplishments of the industrial cryogenic engineers, including such well-known names as Linde and Claude, who developed these processes, constitute an impressive record.

Advances in Gas Liquefaction

At the meeting, in the basically supporting area of gas liquefaction, Professor S. C. Collins of M.I.T., well known pioneer of early cryogenic engineering, reported his current experiments to liquefy helium and hydrogen at "a figure only slightly greater than the cost of liquefying air."

M.I.T. has built a heavy-duty machine for this purpose which will run for years with nominal maintenance. Served by a three-stage 90 horsepower helium compressor, it has a capacity of about 45 liters of liquid helium or at least 50 liters of liquid hydrogen per hour. Helium is the refrigerant gas in either case, the hydrogen being liquefied by condensation on helium-cooled surfaces. Liquid nitrogen precoolant is used at the rate of about 25 liters per hour. Significant feature of the liquefier is the arrangement of refrigerative elements and heat exchangers which provide refrigeration at precisely the temperature level at which it is needed. The M.I.T. equipment is now producing liquid helium for as little as $4.00 a liter compared with at least $25.00 a liter when produced with conventional liquefiers.

Also in the area of gas liquefaction, with emphasis on capacity as well as efficiency, V. J. Johnson gave performance data for the twin 250 liter per hour hydrogen liquefiers at NBS' Boulder Lab. Modern hydrogen liquefiers produce essentially pure parahydrogen rather than normal 25% para which exothermally, and therefore wastefully, converts to the para form during storage. Large-scale production of parahydrogen through use of a catalyst so placed that the heat of conversion is absorbed by the liquefaction process was pioneered at the Cryogenic Engineering Lab in 1952. NBS now has a new catalyst some 50 times as effective as the best previously used and a unique method for installing the new catalyst in the large liquefiers to increase their rate of production as much as 18%.

The new arrangement, tested in one of the liquefiers during several recent runs, was termed "one of the most significant advances in liquefier design since the use of catalysts for hydrogen conversion was introduced on a large scale by CEL". Johnson said that many attractive applications of the arrangement are possible and will be utilized in the design of new and larger liquefiers.

Philips Research Laboratories, Eindhoven, Netherlands has developed an unusually compact, single cylinder, water-cooled apparatus for gas liquefaction which is unique in that the gas does not pass through the working parts, but condenses on the surface of the cylinder head. This permits the production of an exceptionally pure product, free from lubricating oil or similar contamination. Utilizing the cold-gas principle of refrigeration, this liquefier efficiently reaches a range of —80° to —200° C. (—112° to —328°F) in a single stage.

Designed primarily for liquid air production, this apparatus can with simple modification be used for liquefying other industrial "escape" or compressed gases. The rate of liquefaction is determined by the characteristics of the gas or gas mixture. With liquid air, production is five quarts per hour. Dr. Kohler of Philips brought out that this equipment can be of extensive use in research and other laboratories where a continuous supply is used or required. He said that immediate needs can be met quickly since production begins in as little as 15 minutes after starting the operation. Conventional methods require more than two hours before the processes begin.

Low Temperature Processes

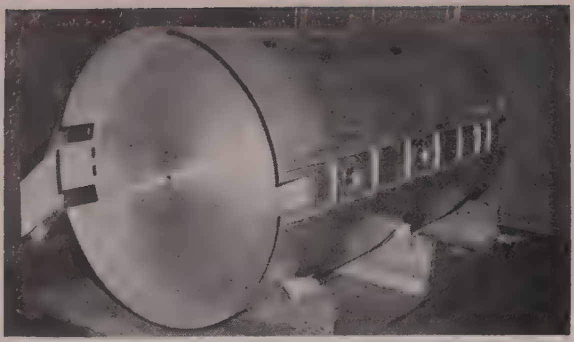
In the separation of deuterium from hydrogen-deuterium mixtures by distillation, NBS engineers hope to show that the production of heavy water on a large scale can be had at a relatively low cost. (Heavy water is a good moderator and coolant for nuclear power reactors.) Their experimental work over the past two years with small laboratory distillation equipment has provided them with the necessary design parameters for the construction of a small pilot plant. Once assembled, they plan on running experiments with low-concentration feeds of hydrogen-deuteride in hydrogen as the final steps in this isotope separation program.

B. M. Bailey of A. D. Little, Inc. outlined another process, low temperature freeze-out purification of gases. A. D. Little's engineers considered the effects of mass transfer and heat transfer in the prediction of heat exchanger pressure drop build-up rates which occur in the freeze-out process. Comparison of these predicted rates with those obtained experimentally showed fairly good agreement. Greater utilization of this process of purification may have far reaching effects in the cost of production of gases such as hydrogen which must be quite pure before liquefaction can be accomplished.

New Tools

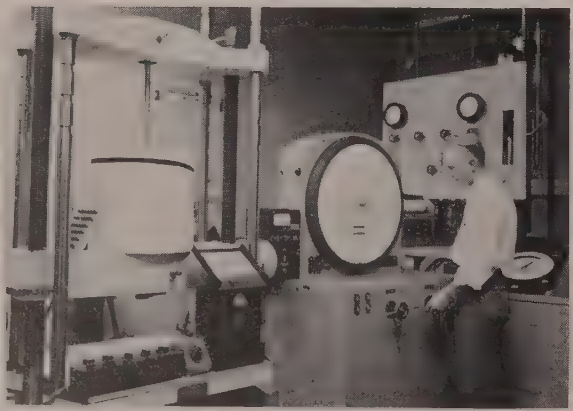
In the last two or three years cryogenic engineers have come up with some new tools about which they literally effervesce. Examples: liquid hydrogen bubble chambers, liquid helium bubble chambers and extremely powerful

MIT's helium-hydrogen liquefier now produces liquid helium for $4 per liter—compared to $25 per liter by conventional methods.



An airborne pressure vessel that holds rocket fuel at very low temperatures in a Bell Aircraft missile.

New gas refrigerating machine developed by Philips Research Laboratories of Eindhoven, Netherlands, liquefies air in only 2 minutes. Left to right: Dr. W. Kohler of Philips and Dr. K. D. Timmerhaus, chairman of the 1956 Cryogenic Conference.



Standard tensile testing machine adapted to test specimens while they are immersed in a cryogenic liquid.

electromagnets cooled by circulating liquid hydrogen through the windings.

In the bubble chambers, atomic particles leave streaks of bubbles to be photographed as they travel near the speed of light through superheated liquid hydrogen or liquid helium. R. L. Blumberg, outstanding U. S. authority on such chambers, gave an account of the 10-inch diameter liquid-hydrogen bubble chamber now operating at the University of California Radiation Laboratory. Blumberg's collaborators were A. J. Schwemin and J. D. Gow. With a depth of six-and-one-half inches and an active volume of eight liters, the bubble chamber fits into a magnet capable of providing a 12,000-gauss magnetic field which deflects charged particles traversing the chamber so that particle momentum may be determined.

The University of California's Radiation Lab has a larger bubble chamber now in the design stage. The larger chamber, allowing more extensive observations to be made of atomic particle interactions (window dimensions of 23 x 75 inches), will contain about 500 liters of liquid hydrogen.

According to D. B. Chelton and D. B. Mann, NBS consultants to the Radiation Lab, a gaseous rather than a liquid expansion system is being planned for the large chamber; a fast recompression method is of importance to make the superheating process more nearly reversible.

"Short superheating times serve both to reduce the amount of refrigeration required and to prevent temperature gradients caused by unnecessary bubble growth," Chelton said. This chamber is to be maintained at the desired operating condition by a closed-cycle hydrogen refrigerator of approximately 2000 watts.

Duke University is working on a three-liter liquid-helium bubble chamber under the combined efforts of W. M. Fairbanks, M. E. Blevins, M. M. Block, M. J. Buckingham, E. M. Harth, and G. G. Slaughter. Characteristic features of the chamber are high bubble density for tracks of minimum charged particles, small bubble size, extremely small expansion ratio, and convenient operating pressure.

Ultra-Powerful Magnet at Los Alamos

Dr. H. L. Laquer is working on an ultra-powerful magnet that has been built at the Los Alamos scientific laboratory in New Mexico. He said that ultimately, by manipulating this magnet which is cooled with liquid hydrogen, the group he works with hopes to cool matter to temperatures lower than any previously attained.

Dr. Laquer explained that the magnet differs from most electromagnets in that it requires only 1/100 of the electric power needed to operate a room temperature magnet of equal size. The magnet coils, when cooled to liquid hydrogen temperature, become excellent electrical conductors. He has attained a steady field of 65 kilogauss with a "jelly roll" type of magnet, 5 inches long, 2½ inches inside diameter, and 7½ inches outside diameter, dissipating 15 kilowatts in free boiling (—423°F) liquid hydrogen.

Working under the auspices of the Atomic Energy Commission on this project, Laquer's program of designing and testing continuously operating liquid hydrogen cooled electromagnets since 1955 has revealed that problems of heat transfer, coil stability, and switching, even when batteries are used to supply the power, have been much less severe than anticipated.

New Industrial Applications

Various types of cryogenic equipment are now headed for industrial applications. Among these is a new and practical application for liquid hydrogen. M. D. Andonian of the Cambridge Corporation revealed how engineers performing work for the Air Force Cambridge Research Center have found a way to replenish a high-altitude weather balloon's lost gas while it is still in flight. They developed a specialized storage container which holds nearly 120 gallons of liquid hydrogen and is attached to the balloon for refueling purposes.

The dewar has a switch that senses when the balloon sinks below a certain altitude because of the loss of gas. When this happens, a valve on the container opens automatically, releasing cold liquid which immediately reverts to gas as it passes through the valve, over a warmup coil and into the balloon. With this refueling device, weather balloons will now be able to remain aloft many hours longer making more extensive observations than ever.

Another equipment problem has been solved by G. F. Tanza of the Garrett Corporation in Los Angeles. He has developed a ball-bearing that operates without any lubrication at temperatures very close to absolute zero and at speeds up to 10,000 revolutions per minute. Mr. Tanza said that the bearing was developed by necessity when his organization needed a small fan to circulate hydrogen gas at a temperature slightly above its boiling point.

After designing and testing 20 different types of bearings, Mr. Tanza arrived at a workable 440 stainless-steel ball-bearing utilizing a micarta retainer. According to Mr. Tanza the bearing will operate continuously for at least 150 hours at temperatures ranging from —420° to 100° Fahrenheit without lubrication.

Airborne Pressure Vessels for Rockets

The aircraft industry was brought into the cryogenic engineering picture by a discussion of design aspects of airborne pressure vessels by R. E. Wong of the Bell Aircraft Corporation. The increasing size and use of rocket power plants in aircraft which require large volumes of fuel under pressure have made the pressure vessels to contain these fuels an important structural component.

Because of the desired economy in weight, the membrane stresses at working pressure are usually made to approach the material yield stress. These stresses, and greater ones at various points of stress concentration, are often repeated and may be sustained for extended periods. This condition is intensified at sub-zero temperatures where the ductility of the material generally decreases with decreasing temperature. Some steels, furthermore, exhibit a transition temperature (change from ductile to brittle behavior) below which their ductility or energy absorption is markedly reduced.

Experience has shown that fusion welding is the most practical method of pressure vessel fabrication. This method of fabrication requires the welds to be in tension. To date, their strength has only been approximated by the usual non-destructive inspection techniques. Bell Aircraft, however, has successfully employed a "volumetric set method" in proof testing. The method requires that the proof pressure be determined experimentally and that it result in a controlled amount of general yielding of the vessel. Advantages gained by this method include an increase in fatigue life by introduction of beneficial residual stresses and by "stretch" forming of the vessel into a more favorable shape whereby stresses introduced by manufacturing inaccuracies such as ovality and local dents are minimized.

Nuclear events in a liquid hydrogen bubble chamber. Typical high speed photographic record of bubble tracks made by R. L. Blumberg permits the study of the interaction of atomic particles with matter.

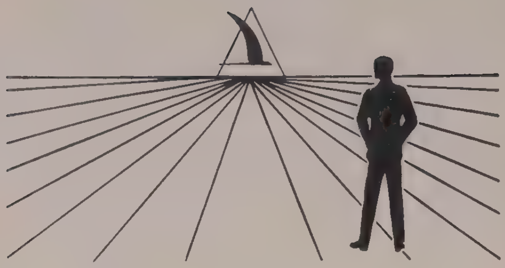
As quantity use of low temperature cryogenic liquids expands, the problem of transporting these fluids becomes important. Vessels ranging in size from a few liters to huge rail, truck, or airborne insulated tanks are now in common use. Latest developments reported at the Conference covered current work on pumps for pushing these super cold fluids from vessel to vessel and studies of insulated pipe lines for transferring liquefied gases for tens of miles. It was shown that once a pipe line is cooled down, the liquids can be transferred over appreciable distances and at a cost which may be less than that involved in the use of transport containers. R. B. Jacobs of NBS directs this work.

Low Temperature Materials

Another broad area for investigation by the cryogenic engineer concerns the properties of materials at cryogenic temperatures. R. H. Kropschot and R. Mikesell of Boulder Laboratories are experimenting with glass. They measured the strength and fatigue properties of BSC-2 optical glass at various temperatures from 20°K to 296°K. Simple beam specimens with two-point loading were tested in both abraded and unabraded condition.

These men found that for a given condition of the glass the breaking stress increases with decreasing temperature. Fatigue decreases with decreasing temperature but still exists at 76°K. These facts will be of value in construction of the several hundred pound optical glass window for the large hydrogen bubble chamber.

Work on the mechanical properties of metals at temperatures as low as one degree above absolute zero is being done by Z. S. Basinski and J. W. Christian of the National Research Council of Canada. Theory and measurements related to temperature and strain rate dependence of mechanical properties of body centered cubic and face centered cubic metals are under study. E. T. Wessel of Westinghouse,



CAREERS FOR ENGINEERS

At Northrop Aircraft in Hawthorne, Southern California, many fine engineering positions are available in electrical design, dynamics, electronics, computing, weapon systems, mechanical design, and structures.

Here are many challenging opportunities, with attractive salaries on fast-growing programs in jet aircraft and guided missile research and development. You'll be on the engineering team of a company that has pioneered for over seventeen years in these fields where continued expansion promises to be fantastic.

At Northrop Aircraft, the progress of personnel is as important as the progress of projects. Your initiative and ambition will be respected. Constantly fresh assignments will be yours. You'll be among friendly people of your own caliber, and you'll be living in sunny Southern California where you and your family can enjoy life at its best, the year 'round.

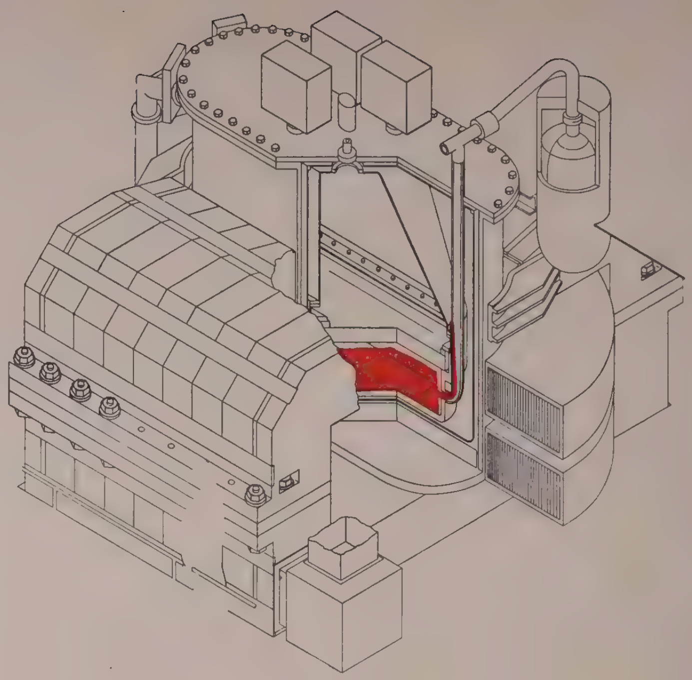
At Northrop you will find the success you are seeking. For complete information about the many career positions now available, we invite you to contact the Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., ORegon 8-9111, Extension 1893, or write to: 1015 East Broadway, Department 4600-A1, Hawthorne, California.

NORTHROP

NORTHROP AIRCRAFT, INC., HAWTHORNE, CALIFORNIA

Producers of Scorpion F-89 Interceptors and Snark SM-62 Intercontinental Missiles

6-A-85



Research in high-energy physics has recently led to the development of the "bubble-chamber", a detection device for elementary particles. Colored area in sketch is liquid hydrogen, the working fluid. When completely developed, it will provide the physicist with a powerful new tool.

R. M. McClintock and D. A. Van Gundy of NBS, and B. Welber of the National Advisory Committee for Aeronautics are working in the low temperature mechanical properties area at their separate facilities.

Insulation systems for cryogenic liquids and equipment are being constantly tailored to specific needs. Jackets evacuated to 10^{-6} mm of Hg with low emissivity surfaces and floating or refrigerated radiation shields are the "ultimate", but there were reports on specially designed powder or foam filled jackets which are cheaper and for many applications almost as good.

Quickening Pace of Cryogenics

Originally, conferences on cryogenic engineering were planned for every two years. But according to some observers, the pace of developments in low temperature methods, equipment, materials and industrial applications is proceeding at such a rate that a yearly conference may prove insufficient. Plans for the 1958 (2 years from now) conference may well be held in 1957. Other observers compare cryogenic engineering with the now fairly mature and rapidly expanding high-vacuum field; they indicate that low temperature applications may result in an industry as large, if not larger. It may also equal in dollar-volume the amount of effort currently spent in high temperature work since studies extremely close to absolute zero are easier (relatively) than investigation at ultra-high temperatures. "We do not have the containment problems over which our high temperature colleagues are currently perspiring. For this reason, and because we can approach our ultimate limit easier, we should be able to amass the data we need for a better understanding of phenomena at these low temperatures and then begin to use them to solve some of our every day problems in the production of new and improved products and processes. Keep your eye on cryogenics". END

R/D CONTRACTS

In this issue Research & Engineering *inaugurates a new service to its readers. Short notices will be published on research and development contracts let by the Armed Forces, other government agencies such as the Atomic Energy Commission, and private industry. Since more than 50 percent of the money spent on R/D in this country is controlled by the military, knowledge of these contracts will help technical management to understand the direction and extent of this effort. In addition, many firms can use this information for leads in obtaining R/D sub-contracts, often more desirable than the prime contract. Where possible, the reason for the R/D and the amount of the contract will be given. May we please have your comments on this new department?*

Remote Control Guidance for Drone Aircraft

The Air Corps drone aircraft are useful as targets for missile firings and for gathering atomic cloud data in nuclear tests. However, guiding the drones by remote control requires an intricate system of microwave command guidance. To develop such a system capable of controlling drones at supersonic speeds, the U.S. Air Force has enlisted the aid of the Sperry Gyroscope Company of Great Neck, N.Y. The contract amounts to more than 4½ million dollars.

Atomic Fire Fighting Equipment

Large scale fires such as may result from an atomic explosion will require special fire fighting equipment. To develop such equipment, the Army Corps of Engineers has awarded a contract to the Consolidated Diesel Electric Corporation for three trailer-mounted units. Each unit will provide 60 kilowatts of power, a gasoline engine which turns continuously at 3600 revolutions per minute, and a cylindrical electric fire pump especially designed to fight fires resulting from large scale explosions.

Gas-Cooled Reactor

The Aerojet-General Corporation of Azusa, California will design and build a gas-cooled reactor for the Atomic Energy Commission. The gas-cooled concept is one of eight ways the A.E.C. has chosen to package power reactors for civilian power plants. The experiments will be conducted at the National Reactor Testing Station in Idaho. Twenty other companies submitted bids for the contract.

Radio Telephones for Farmers

The cost of stringing telephone lines in rural areas is extremely high. As a result millions of farmers are forced to do without telephone service in some regions of the country. To correct this situation, the Rural Electrification Administration hopes to develop radio telephoning in these areas as soon as possible. To further this goal it has commissioned private telephone companies to develop equipment that will allow farmer to dial by radio directly into telephone switchboards.

Instruments for Atomic Subs

Under the high-temperature radiation that occurs in atomic submarines such as the Nautilus, instruments must measure extremely critical temperatures, pressures, and liquid levels in the coolant loop of the submarine's reactor. To develop instruments that can handle the job, the Navy Department plans to spend $350,000 to advance the development of super-sensitive instruments in atomic submarines. General Electric's Instruments Measurement Laboratory in West Lynn, Mass., will undertake the study.

Inlet Diffuser Control for Turbojet Engines

Shock waves that form ahead of the jet inlet is one of the serious obstacles to supersonic flight. To overcome this barrier, the Wright Air Development Command at Wright-Patterson Field, Ohio, has awarded a research contract to the Aeronautical Division of Minneapolis Honeywell Regulator Company. The object of the contract is to find a way of controlling the inlet diffuser of turbojet engines by insuring maximum recovery as shock waves form ahead of the faster-than-sound aircraft.

Other sections of the contract call for:

- determining inlet control variables
- relating the findings to other systems and controls
- relating the findings to electrical, hydraulic, pneumatic and ram air power sources.
- simulating all of these conditions on the firm's analog computers, and
- constructing models for high temp and actuation tests.

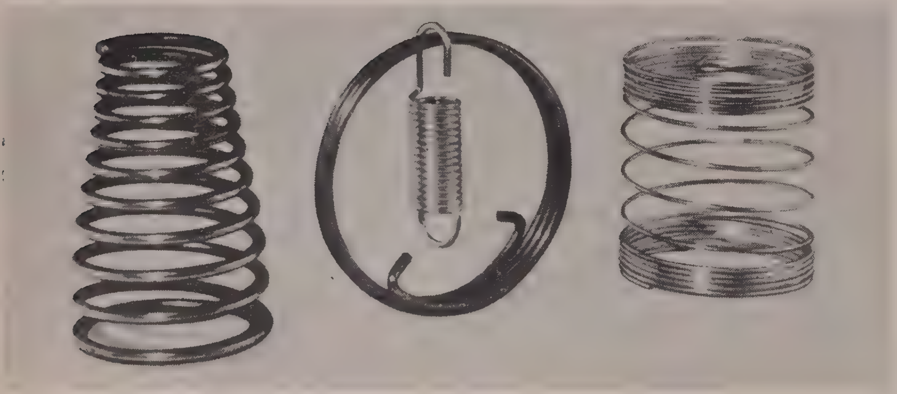
Adhesion

Wright Air Development Center has also commissioned the Evans Research and Development Corporation of New York City to study adhesion. The first phase of the research calls for determining the surface energies of polymers and metals by use of solid-state creep.

Remote Control Instruments for Reactor

Because it contains a high degree of fissionable material and burns fairly slowly, the fuel in the fast breeder power reactor is capable of being reprocessed by cycle pyrometallurgy. However, the fuel in this reactor is highly radioactive and requires handling by remote control. To develop remote control instruments for use in the fast breeder reactor, the Atomic Power Development Association, Inc., has commissioned the Equipment Division, National Research Corporation to study the problem.

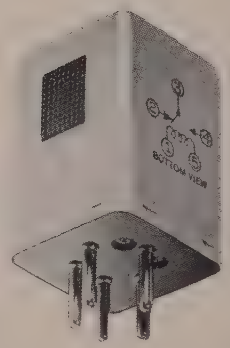
COMPONENTS



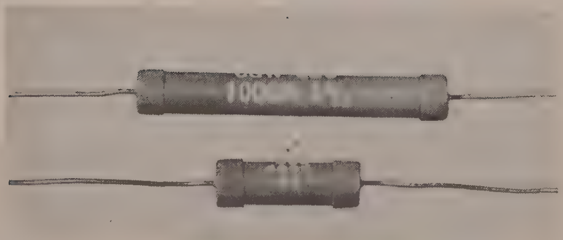
Better Springs

These two types of springs offer improved features for designers. "Trucoat" springs have a light gray coating that provides lower out-of-round characteristics than conventional music wire. "Micro-Tin" springs are a more uniform corrosion-resistant type for precision use in instruments, business machines and similar applications.
Developer: National-Standard Co., Niles, Michigan
For more data circle 27 on page 48.

Photoelectric Relay



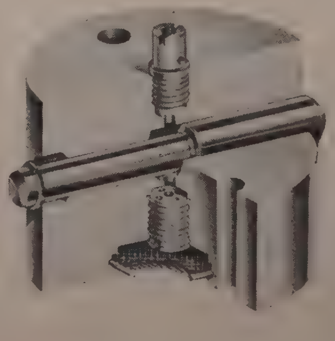
Operating at light levels of five foot-candles or less, this "Photorelay" could be used in a number of devices such as weighing, automatic bottle washing, and bagging machines. A Cadmium Sulfide photocell is the light-sensitive electron source. Operates as fast as twice a second.
Developer: Sigma Instruments, Inc., 59 Pearl St., South Braintree, Boston 85, Mass.
For more data circle 25 on page 48.



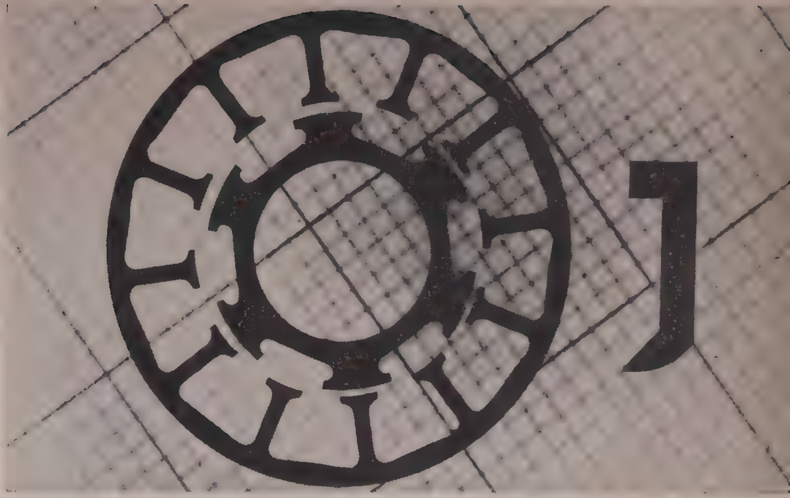
Resistors With Wide Temperature Range

Capable of operating at temperatures up to 200°C, these precision resistors have a temperature coefficient of only ±300 ppm per degree C. The core is a Pyrex glass rod with metallic oxide bonded to it. The units meet the requirements of MIL-R-11804B.
Developer: Corning Glass Works, Corning, N.Y.
For more data circle 22 on page 48.

Only One Moving Part

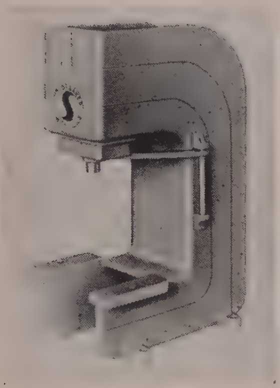


This piston pump for continuous lubrication of bearings has only one moving part. Designed primarily for machines with a vertical drive shaft, it is only 3" in diameter.
Developer: Bijur Lubricating Corp., Rochelle Park, N.J.
For more data circle 20 on page 48.



Laminations

These special rotor, stator and recording head laminations are carefully ground to eliminate burrs and provide good stacking characteristics. Concentricity of the rotor laminations can be held to 0.005". They are made of a nickel alloy for high permeability.
Developer: Magnetics, Inc., Butler, Pa.
For more data circle 21 on page 48.

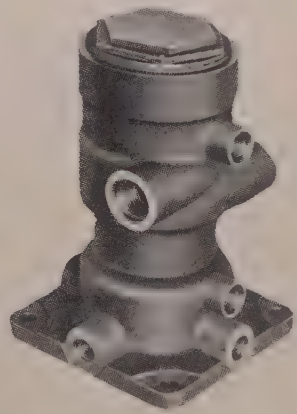


Uses 25% as Much Air

Machine tool developers should study this pressure booster assembly which saves compressed air in advancing a ram to contact the work piece. It works by using little pressure to advance the ram at high speed before full pressure is applied. Called the "Speed Press", it comes in sizes to handle 10 tons.
Developer: Studebaker Hydraulic Products Co., 1733 North 33rd Avenue, Melrose Park, Illinois
For more data circle 23 on page 48.

Hydraulic Motors

Designed for aircraft, these constant displacement axial piston type hydraulic motors operate at 3000 psi. Suitable for continuous intermittent or continuously reversing duty cycles.
Developer: The New York Air Brake Company, Watertown Div., Watertown, N.Y.
For more data circle 24 on page 48.



Works at 200°C

These miniature silicon rectifiers operate at ambient temperatures from −65° to 200°C. Developed for military use, they handle 1000w. Leakage current is less than 1/1000 the forward current. They stand up to 500g shock.
Developer: General Electric, Syracuse, N.Y.
For more data circle 26 on page 48.

WALL STREET LOOKS AT R/D

Ora C. Roehl

Today, institutional investors are certain that in many industries the quality of a company's research is a primary determinant of its valuation in the securities market. Sometimes the short-term reactions of the securities market to new research developments are not too logical; such was the case when the market for General Electric Company stock went up a few points when the company announced the production of synthetic diamonds; or when the market overdiscounted the importance of the new soil conditioners a few years ago; or when the stocks of many companies entering the antibiotic field were substantially overpriced. The securities market may for short periods be wrong in its evaluations, but in the long run it has a way of being quite correct.

While the securities market may provide a good long-term index of the overall quality of a company, the objective of every financial analyst is to expedite the appraising process and to anticipate the "dictum of the market". The financial analyst is, therefore, concerned about the quality of a company's re-

The general public may just be coming aware of the significance of research and development in the nation's economy, but the financial world's security analysts have been pinpointing the value of R/D for years. Here, a man responsible for investing hundreds of millions of dollars tells how an analyst goes about evaluating a company's R/D effort.

search. For, if he is right in his evaluation of its R/D at least in research dependent industries, he is bound to be right about the company's future performance in the security market.

The financial community is aware of the importance of research in our industrial economy. In the investment company business our success is also determined by the quality of our research—our investment research. If our security selections are poor, our results will be poor and that fact is soon reflected in our business and in the market price of our shares.

The importance of security selection can be seen by looking at the price performance of securities in one or two key industries. See the examples in the box on this page.

In our competitive economy, companies are continually going up or down; few standing still. A Brookings Institute study showed that of the 100 leading companies in 1909 only 36 were still near the top or even in existence in 1949. As one looks over the action of the securities market since 1946, it is of more than passing interest to note that not many more than half of the securities are selling above their '46 highs. The securities market has always been selective and is becoming more so.

While many factors account for the difference in performance of the companies just mentioned, the overall effectiveness of the research and development programs of the individual companies was one of the primary reasons why the best performing security did so much better than the securities of the other companies. In two of the industries both the leading company and the poorest company spent about the same amount on R/D.

Institutional investors are, therefore, continually trying to evaluate the research and development work of the companies in which they have an investment, or in which they contemplate making an investment—the main point of our discussion. *"Just how do institutional investors attempt to evaluate the R/D factor in analyzing a company's securities?"* Let's consider:

- The importance of management.
- The factors that a security analyst considers in evaluating research and in obtaining an overall picture or feeling of the importance of research to the company under review. Let's break this up into two parts—(a) factors affecting the specific company; and (b) the broader industry factors.
- Then let's review a few questions that analysts like to discuss with management; factors on which we feel they should be informed if they are truly research conscious.
- Next—a few case histories may help illustrate the role research evaluation is playing and has played in determining the market value of securities.

The General Management Factor

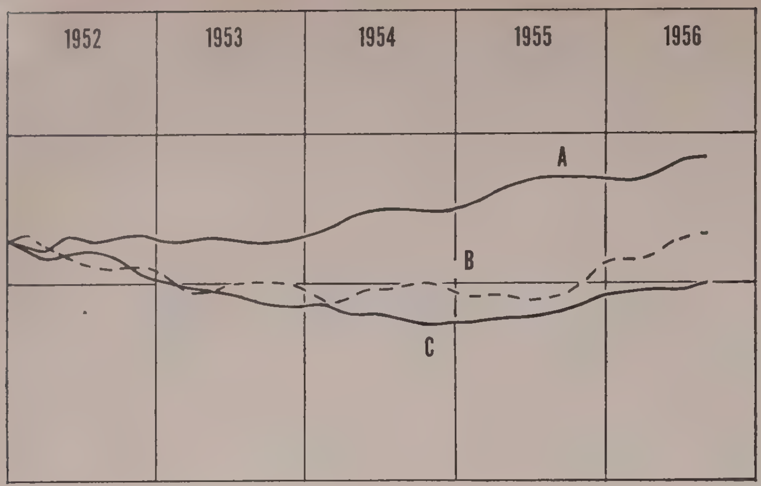
First, every analyst desires information on management's attitude toward research and development. We all know that R/D can't flourish unless top management climate is favorable. We also like to know about the research staff—great developments are not the result of a "flash of genius" but rather the result of organized creative thinking. We're interested in knowing why a research director, for example, leaves a company and why another company may have employed him. (This can be good for both companies.) We like to know about a company's executive salary scale because that often indicates the relative evaluation management places on various corporate endeavors. We like to know if the research director was hired or has his job primarily because of his administrative abilities. Does he bring something more to his job? Does he, for example, have something to add to the company's growth potential? Is he broad enough to add fire when needed to the company's growth enthusiasms and plans? Is his personality and status in the company such that he can make his voice heard?

We like to know whether or not the President, the Vice President for Sales, the Vice President for Production and other key officials appropriate a portion of their time to the company's research problems. We like to know how management evaluates R/D, whether or not technical men are on a par with the financial, legal, sales and production departments. We like to know what organizational device is used, such as a Research Committee, to coordinate and obtain support not only for R/D activities, but to give research the benefit of the advice of the other departments.

Management is the most important single factor in security analysis and it is definitely true that **who** is behind the balance sheet is usually more important than **what**. Just what makes a good management team varies from industry to industry, but in the research dependent industries no management could be rated good or excellent that was at all lacking in its appreciation of the importance of research. At the same time a company that is strong in research, perhaps headed by a research man, may be so poor in general managerial ability that it would not be a good investment.

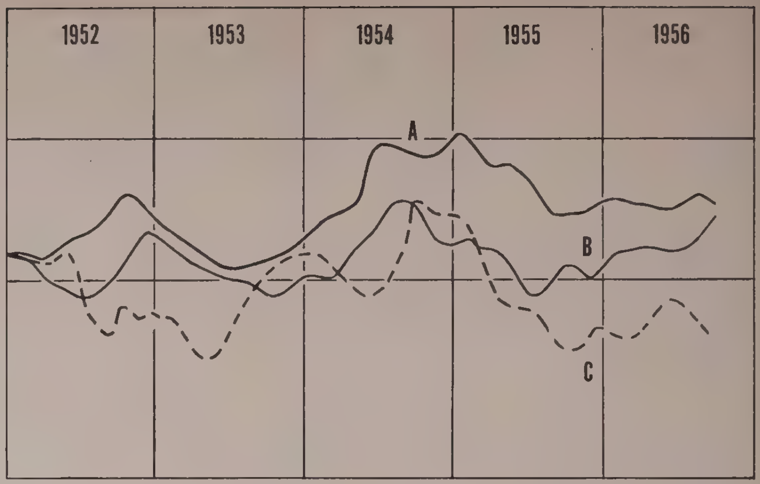
Superior management is a scarce commodity. Superior management is generally evaluated at 30%-35% higher in the securities market place over average management and good management is worth at least 15%-20% more than the average. This fact can be of importance to a company that needs to spend huge sums on basic and applied research to improve its present products and to create new ones since

$100,000 invested in Oil Company #1 in 1952 is now worth $250,000
$100,000 invested in Oil Company #2 in 1952 is now worth $174,000
$100,000 invested in Chemical Co. #1 in 1952 is now worth $192,000
$100,000 invested in Chemical Co. #2 in 1952 is now worth $120,000
$100,000 invested in Chemical Co. #3 in 1952 is now worth $142,000
$100,000 invested in Drug Company #1 in 1952 is now worth $ 71,000
$100,000 invested in Drug Company #2 in 1952 is now worth $462,000
$100,000 invested in Drug Company #3 in 1952 is now worth $229,000



Relative Price Performance of Three Large Chemical Companies

Company A has shown excellent performance not only since 1952, but also for the past 15 years. Its products have been based on research and its new developments have been fully discussed by the company with its shareholders. It has been a leader in scientific discussions within the chemical industry. Company B, long a leader in chemical research, over the past 15 years, has not been able to translate a high quality of research into profits. Starting in 1954 management began to solve some problems through acquisitions and better planning. Recently, the company's stock has been looked upon with more favor and its relative performance line has started up. Company C is also largely dependent on research. However, its research has been confined to relatively unprofitable fields and as a result the price of its stock has been downward for most of the past decade. A few years ago management took inventory of its entire business and redefined its areas of research and operation with the result that a new life and spirit has been infused. This is now making itself felt in sales and profits, and its relative performance line after a few false starts now appears to be in a very sound upward trend.



Market Action of the Common Stocks of Three Relatively Small Companies.

All of them are practically 100% dependent for their success on the quality of their research work. The future success of Company C is almost entirely dependent on its selling research and development work to other companies. Market action of its common stock has been and is very volatile even when compared to 247 other volatile issues. As can be seen the market questions the real attractiveness of Company C as an investment. Even though the stock has had a number of sharp rises it is today selling, on a relative basis, under where it was five years ago. Companies A and B are competitive with one another. Both have excellent research staffs and both are fortunate in that their managements have that rare quality of being not only good research men, but also competent business men. Both companies have spent about double the industry average on research but Company B has substantially stepped up its research expenditures in the last year, with favorable results in the securities market; its relative performance since the spring of 1955 is better than Company A.

debt and equity funds can be raised at much lower costs—and right there the research department of a well-managed company has a head start on the research department of a company not as highly regarded.

Company Factors—

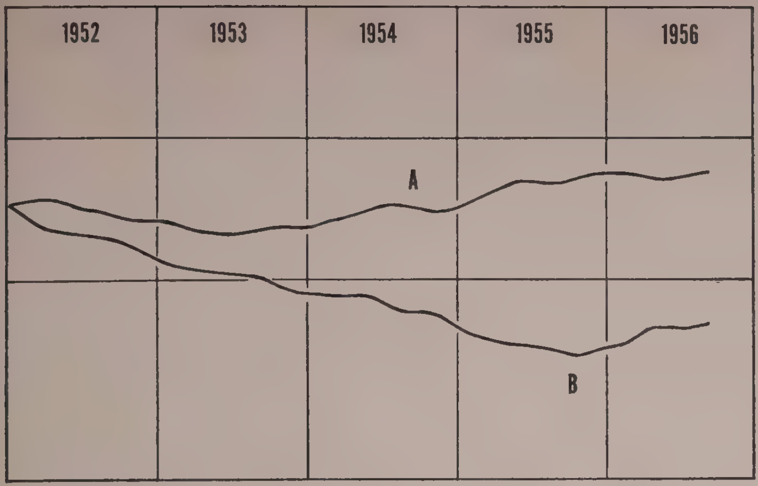
Now let's become more specific and discuss a few of the factors a security analyst considers in making his "research" evaluations.

- The money spent for research is broken down, if data are available, by areas and types of research. Efforts are made to pinpoint money spent for basic research, product improvement and the creation of new products. These data are compared to similar data for other specific companies and for the industry. Information comes from company managements, annual reports, trade and engineering publications, government reports and from various special reports such as the excellent studies made by Harvard a few years ago.

- As past achievements and current trends of a company's business are important factors in research evaluation, running analyses of operating income and expenses determine the trend of profit margins and check the sale trends of the company's old and new products.

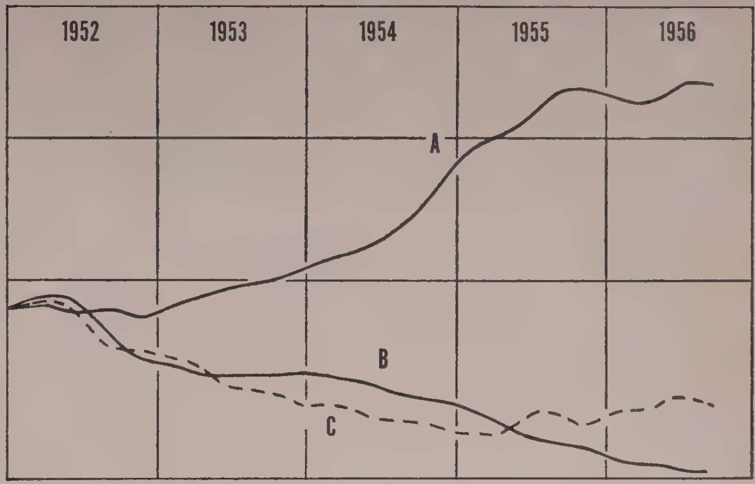
- Cash flow and other special studies determine the amount of cash that the company may have available and may need for additional research and for capital improvements. These studies cover cash generated by the company with estimates of bank and other credit available as well as the possible issuance of additional stock. In a research dependent company, reported earnings per share may mean little. The analyst must dig deeper. He must consider the cash coming in from accelerated and regular depreciation. He must not only review research expenditures, but he must also look at the sales and marketing costs to determine if these are temporarily high because the company is establishing a new sales force and improved marketing methods to sell the new products developed by its research. Often times such expense along with research expenditures should be considered money invested rather than expense. However, these are difficult areas to evaluate; so much depends not only on the quality of the research, but also on the quality of management's efforts to put the research results into production and to turn them into profits.

- Another fruitful exploration is an analysis of the company's capital expenditure budget. Here is another picture of the company's growth pattern. What percent, for example, of the budget is for the production of new products? What percent for older products? What profit margins are expected from the new products? What percent must be spent or is being spent to make or keep the company competitive with others in its business? How do R/D expenditures of the past correlate with capital expenditures of to-



Relative Action of Two Chemical Company Stocks.

For the past 10 or 15 years these stocks have always shown up poorly in comparison within the chemical industry. Company A changed management four or five years ago and from a company dependent on highly cyclical products, has so diversified its business and improved its research that the security market is giving a much higher evaluation to its common stock. Company B has also shown a very poor relative performance for many years. Its performance was poorer than average from 1952 almost to the end of 1955. During the past few years the management of the company's Research Department has been changed and a well conceived program of expansion has been started. A question, however, remains as to whether the company's new management will continue to have the support of the board over the three or four years it will take to carry out the program started a year ago. So far the security market thinks that management will be able to do what it has set out to do and the relative market action line of its common stock is up quite sharply since the beginning of the year. The movement of this line in the next year or two will very likely be quite sensitive to management's ability or lack of ability to produce some of its very promising R/D.



Relative Market Performance of Three Large Drug Company Common Stocks.

Company A has been very outstanding in its research work. Research areas were chosen with care and a competent marketing organization distributed the products developed. Company B has also long been active in research, but for the past five or eight years its research has not been too profitable or resultful. Up to the present, even though it is spending considerable sums for research, there is no indication that a change is taking place within the company and so a reversal of the downward trend of its relative security market action line does not appear probable. Company C has been a long-time leader in drug research, but its work has also not been in the areas of great growth. While some of its developments have been excellent, its competitors have been able to more effectively market similar products. However, in the past year indications are that its downward trend has been reversed—something not evident in Company B. Great differences in performance between Company A and Companies B and C show how important it is to the investor to have his money invested in the company fortunate or astute enough to be in the right research areas.

day? All of these checks give some hint as to the quality and the status of a company's research work.

• Various special studies of specific questions are also made from time to time. For example, a check of the number of patents issued to the company year by year determines the number of patentable ideas developed. While these studies may not be too meaningful by themselves, such special reviews give clues to the company's progress.

Broad Economic and Industry Factors

The analyst must review basic economic developments and must have some understanding of the growth trends of specific industries or of specific end products. A few examples of such broader economic factors are:

• The basic current growth trends of the nation's economy are under continual review and in this field the analyst usually obtains help from his company's economist. If, for instance, the agricultural income picture is not favorable then the demand for commercial fertilizers may decline. A company may have developed important new and improved production processes through its research, but it may not be able to fully capitalize on such developments, as it may be faced with an excess of supply over demand. Each specific company must be analyzed separately. A decrease in fertilizer demand will not affect a potash company with many new developments under way to the same extent that it would a company producing only anhydrous ammonia for agricultural use.

• The analyst must know the supply and demand for specific products. He must first have some basic ideas on the economics of other plastics—styrenes, acrylics, vinyls, alkyds, urethane, ureas, phenolics, melamines, silicones, and polyesters. He must make studies of the present and possible future markets for polyethylene products, and weighs this against the present and future supply. He must weigh the competitive advantages and disadvantages of companies using, for instance, the Imperial Chemical Industries process, the Ziegler process or the Phillips process. After studying the entire picture he may conclude that the growth trends in the field are so strong that an investment in a well-run company doing basic research, for example, on new and improved catalysts would be a good investment. The point is he must look at the entire field and not some facets.

• Two other less complex examples will illustrate the points we are discussing. We try to have our Economics Department make continual studies of growth trends in various segments of the economy, and two very simple and important ones come to mind; namely, the long-term growth in the aluminum and high temperature metals fields. In the aluminum field the analyst might decide that aluminum investments in general are attractive and in the high temperature fields he might conclude that companies that are not only leaders

in research but who also have good basic positions in raw materials, such as International Nickel and Climax Molybdenum, might be the answer to his investment problem, if participation in these fields is desired.

Having done what work he can do on his own, the analyst also discusses the research activities of the specific company with the company's management and with consultants and specialists in the particular field. Only then will he have enough information for a sound investment decision.

- The analyst must be familiar with the demand and supply for specific end products as, for instance, polyethylene.

Research Discussions With Management

The financial analyst likes to obtain some idea of management's grasp of the company's research work and problems. Here are a few things that competent management should know about its research activities.

- Competent management would have detailed information available on the company's growth plans along with specific information as to where research fits into such plans. For example, one oil company may determine it is going to be interested in everything based on petroleum; another may decide to confine its work to a more limited field. Management would have a definite idea of where it stands today—where it is headed, and to what areas its research activities are to be limited. Management would know whether the area its research covers is in highly competitive fields or in areas where competition may not be quite so potent and more in line with the company's capabilities.

- Management would have a definite understanding of the effectiveness of its research work. It would know the number of its new products or product improvements compared to its competition. It would have definite ideas as to the product life of its new developments—something that many companies do not seem to have.

- Management would not only know what part of today's business has come from products developed in the past decade, but it would also know (maybe not for discussion or publication) what business it had lost by not being in the forefront in all of its fields.

- Management would know the sources of its new products—did they develop from work done originally by its competitors; from university research; from government research; from foreign sources; or from its own R/D?

- Management would know what its problems are today and in the future. What plans should be made now and what research funds should be committed for the future? The company's management would be able to talk about the new products and product improvements required in the next five or ten year period—and also the programs to satisfy these requirements.

- Management would also have plans for financing and marketing the products of its research. How is the new product to be sold, engineered and serviced? (This might require an entirely new marketing organization.) Often insufficient attention is given to these questions not only by technical management, but also by top management.

- Management would have some general but at the same time specific ideas as to its growth philosophy. Is growth to come largely from within or by acquisition? If by acquisition just how would the company to be acquired be integrated into the company's other operations? Would the new research development from within or the new acquisition make a real contribution to the company's business—or would its net contribution be relatively unimportant and in effect be lost among the company's many other diverse activities? If every research minded management has these factors at its finger tips, an analyst can't help but give a high evaluation to the firm's R/D activities.

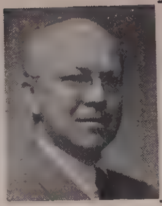
Specific Case Histories

The charts in this article show the relative market performance of securities compared to other companies of comparable investment quality. As the lines on the chart go up the stock is performing better than average; as the lines move down, the security is doing worse than average. (Average of all the issues is a straight line.) All security analysis work is really comparative in nature. A security may go up in price but if the price rise is not as great as that of another issue of comparable quality, the relative performance of the security in question will be poor. In the charts the relative price action of a number of securities is shown and while factors other than the quality of a company's research have a bearing on the price of a company's stock, in the examples chosen an attempt has been made to select issues where the R/D factor is of primary importance.

Take The Analyst Into Your Confidence

One of the main problems that a financial analyst always has is the problem of obtaining good information. While most company managements are very helpful in working with the analyst, yet other companies seem to lack the necessary know-how or they may feel that the less said about their problems, plans and operations the better. Sometimes the executive with whom the analyst visits does not have a real understanding of his company's R/D program. We have found company treasurers who have indicated that their company's research and construction plans cannot be talked about even though the technical and general trade magazines may have published articles giving complete details. Other companies, on the other hand, are sometimes so optimistic about their possibilities that they may paint too bright a picture of the future. The ideal company, of course, from our point of view is one that discusses frankly not only its successes but also its problems. The managements of such companies take their shareholders and potential shareholders into their confidence and freely discuss not only their present R/D work, but also their plans for the future. The investment company analyst naturally prefers to recommend investments in such companies for he has a feeling of confidence in the management and he also has sufficient information.

Good financial public relations can mean a great deal to a company, for its reputation in the financial world is well worth maintaining and building. Superior management is evaluated at least 30 percent higher in the security markets over average management and in research-based industries the premium paid for superior research and management is often much greater.



Starting as a research engineer in 1928, Mr. Roehl advanced through a varied business career to become head of investment research for Keystone Custodian Funds, Inc. of Boston in 1946. He is now Vice-President in charge of investment research and supervision for 10 funds with assets of $335,000,000.

the future of your company depends . . . on the men who read

RESEARCH & ENGINEERING
FOR RESEARCH & DEVELOPMENT MANAGERS

You know how important new product and process development has become in your own company – that the very future of your company depends on it. This is just as true in thousands of other companies—and has resulted in the creation of –

a group of men who ten years ago didn't exist!

Who are these men? They are Technical Managers—the engineers, chemists and other technically trained men who, now moved up to the department manager level, are directly responsible to top corporate management for new products and processes.

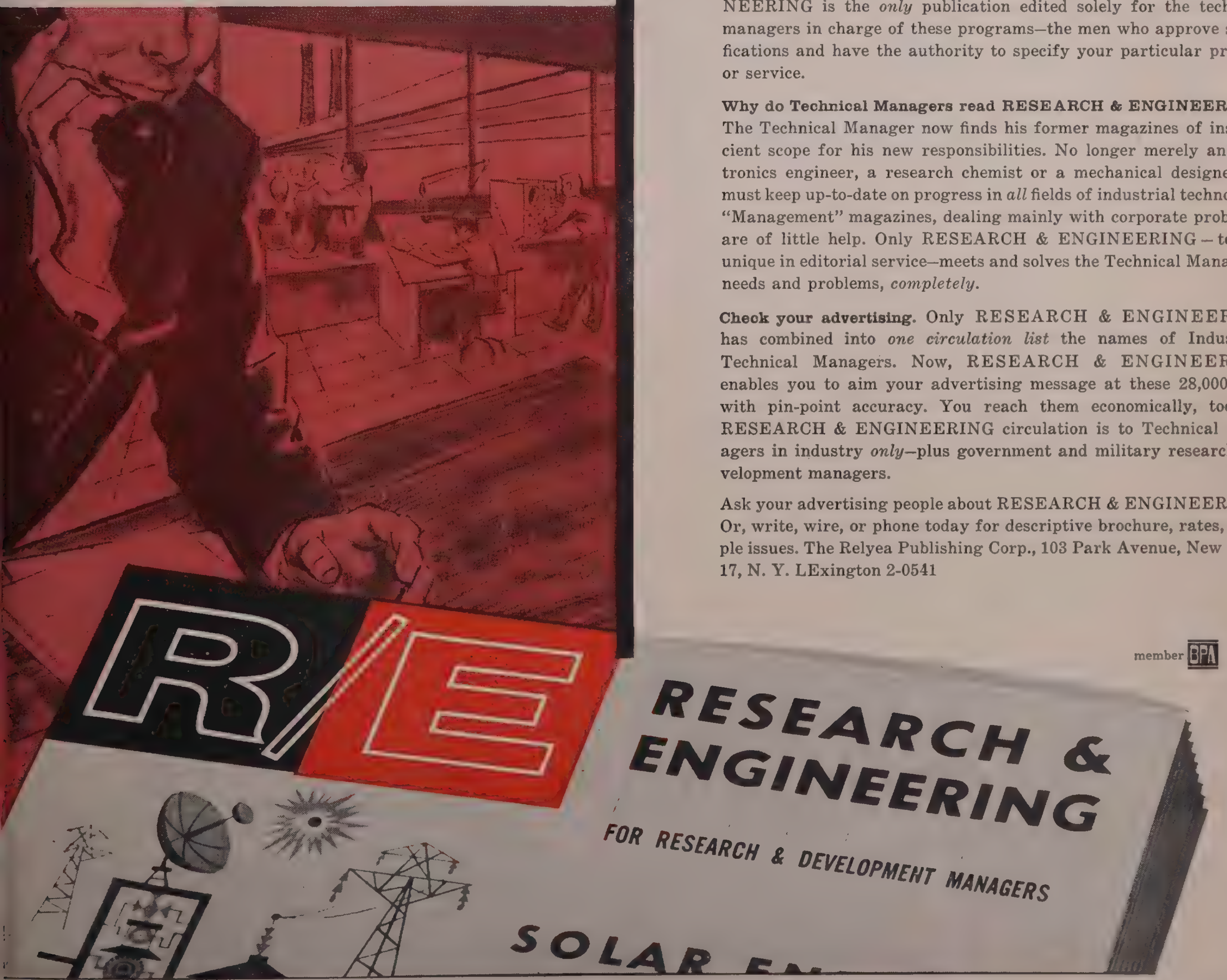
Why do these men now affect your sales? Companies all over the country are planning changes in plant or products. Their Technical Managers – responsible for the success of these programs – must approve every component part: materials; chemicals; instruments; equipment; finishes; machines; devices—anything that affects the performance of the product or process. And RESEARCH & ENGINEERING is the *only* publication edited solely for the technical managers in charge of these programs—the men who approve specifications and have the authority to specify your particular product or service.

Why do Technical Managers read RESEARCH & ENGINEERING? The Technical Manager now finds his former magazines of insufficient scope for his new responsibilities. No longer merely an electronics engineer, a research chemist or a mechanical designer, he must keep up-to-date on progress in *all* fields of industrial technology. "Management" magazines, dealing mainly with corporate problems, are of little help. Only RESEARCH & ENGINEERING – totally unique in editorial service—meets and solves the Technical Manager's needs and problems, *completely*.

Check your advertising. Only RESEARCH & ENGINEERING has combined into *one circulation list* the names of Industry's Technical Managers. Now, RESEARCH & ENGINEERING enables you to aim your advertising message at these 28,000 men with pin-point accuracy. You reach them economically, too—for RESEARCH & ENGINEERING circulation is to Technical Managers in industry *only*—plus government and military research/development managers.

Ask your advertising people about RESEARCH & ENGINEERING. Or, write, wire, or phone today for descriptive brochure, rates, sample issues. The Relyea Publishing Corp., 103 Park Avenue, New York 17, N. Y. LExington 2-0541

member BPA



PUBLISHER'S NOTE: The above advertisement appeared in the October issue of *FORTUNE* magazine—another effort on the part of *RESEARCH & ENGINEERING* to bring home to top management the importance of R/D in today's industrial picture. If the corporate management, or advertising people in your company do not regularly read *FORTUNE*, perhaps you would like to mark this page for their attention.

THE CAUSE AND CURE OF EXECUTIVE INSOMNIA

For some busy R & D managers, insomnia may be a real occupational hazard. This article banishes some common superstitions about sleep and discusses how you can lick insomnia through recognition of the four basic sleep patterns.

Luis J. A. Villalon
Management Affairs Editor

With the license accorded to poets and other non-scientific characters, William Shakespeare philosophized that "Sleep . . . knits up the ravell'd sleave of care"—and then proceeded to state that "Where care lodges, sleep will never lie."

Despite the seeming inconsistency of these two statements, many of today's high-pressured executives will swear on a dozen memos that both statements represent stark, uncomfortable truth. For insomnia, although it doesn't appear in the vital statistics lists and is dignified by no ballyhooed efforts to banish it, is a real occupational hazard for the busy manager. Chronic sleeplessness doesn't rate as much sympathy as a case of ulcers or a tricky heart, but it can often interfere just as much with an individual's effectiveness.

And the trouble is, as Shakespeare pointed out, the fellow with the cares—the personnel problems, the business tensions, and the hard-to-answer questions—needs his sleep most, but finds it most elusive. The common laborer or the elevator operator, on the other hand, usually sleeps like a baby.

The busy executive tries both to court sleep and to cheat sleep. He attempts to burn the candle at both ends, driving his hard-pressed brains beyond a normal pace, and then expects to turn sleep on like the tap of a shower bath. When it doesn't work, he pays for it in reduced productivity. And his staff pays through the results of his shortened temper.

From the minimal amount of scientific research that has been accorded it, and the forest of folklore that obscures it,

one would never realize that sleep accounts for almost one-third of a human's life.

Even the scientific-minded tend to be slaves to the old wives' tales of sleep. And, since a large part of the average insomniac's trouble is worrying about his own sleeplessness, it is important that he be informed as to the real nature of sleep and how to woo it scientifically.

Relatively recent research at several leading U. S. universities has dredged up enough information about the non-waking hours to isolate some of the sleep fables and to discuss causes and cures for several of the leading varieties of insomniac. Science—short of the use of drugs or hypnotism—still can't put man to sleep, but it can give a thinking individual the facts he needs to put himself on the road to more restful slumber.

Superstitions About Sleep

First step in sleep therapy is to banish the superstitions that have grown up around the institution of sleep:

(1) *"I don't sleep a wink."*

Even if you can remember hearing the cuckoo clock croak out the hours, the chances are you didn't have a really sleepless night, but simply experienced typical sleep. Waking and tossing are typical. It's the rare person who sleeps "sound" all night, and it's quite possible to get all the rest you need in a series of deep catnaps, plus some dozing and wakeful resting—if you don't spend your dozing and wakeful time worrying about it.

Research shows that the average man awakens to part of his environment about 35 times a night. The brain is never completely asleep. A sleeping man can brush away a fly or pull the blankets around a cold shoulder. The main difference is that some people remember doing these things and others don't. The average healthy teenager, completely devoid of office cares, rests only about eight minutes between each toss and turn (as determined at the Mellon Institute). Yet, when the executive becomes conscious of such a sleep pattern, he worries about it so much that he doesn't sleep at all the next night.

Another study, in which more than 100 people were observed for two years, shows that the typical sleeper seldom lies still for as long as an hour in a night. He changes from one position to another from 20 to 45 times during a normal night. Half of his varied postures are held for less than five minutes, 20 percent for from five to 10 minutes, and ten percent for from 15 to 20 minutes. This amount of tossing, which is considered moderate, serves a useful purpose in allowing complete relaxation of a complicated muscular system. But the man with too acute a memory often confuses it with that "winkless" sleep.

(2) *"I can get along without sleep."*

Everybody needs sleep. He doesn't necessarily need it in eight-hour sessions, and may get it instead in short snoozes all through the 24 hours, but he can't go without it. The man who insists he works even better when sleepless for long periods is precisely like the martini drinker who fancies he becomes a brilliant conversationalist after the third potion. Both are fooling themselves. They *think* they are operating properly, but research shows them far below par in all important mental and physical reactions.

It is possible, by using up reserve energy, to maintain reasonable efficiency for as much as 72 hours, with or without the aid of sleep-banishing drugs like benzedrine. But then comes the inevitable crack-up of a fatigued mind, as the body's waste products begin to accumulate faster than the body is able to burn them. This condition creates the toxins of fatigue, actual poisons that cause the mind to falter, hesitate and strain.

Precisely this same process—the forcing of body fuels to burn at excessive speeds—occurs in both asphyxiation and alcoholic stupor, but no one in his right mind actually believes he can work efficiently in either condition.

Don't be deceived by the stories of famous men who didn't need sleep, or at least said they didn't. It's well-known that Edison, who burned a good many midnight kilowatts, was a chronic catnapper—and apparently an efficient one.

(3) *"I can't drink coffee and sleep."*

Coffee, like most physical causes, usually gets more blame for sleeplessness than it deserves. Sometimes giving up these pleasant habits, and brooding about it, contributes more to insomnia than would the actual effects of a small amount of caffein. Scientifically speaking, the effect of caffein or any other stimulant is directly related to the proportion of the amount taken to body weight and metabolism. The caffein doses that make dogs dizzy in the laboratory equal 50 cups of coffee for a human.

There's the same danger in becoming over-concerned with strict cures for insomnia. In many cases this merely contributes to excessive preoccupation with one's sleeplessness and makes it more difficult instead of less difficult to get a reasonable amount of sleep.

(4) *"He who is most difficult to awake sleeps best."*

It used to be thought that a sleeper's imperviousness to noise was the best measure of the depth of his sleep. Back in 1862, a German medical student measured the height from which he had to drop a pendulum hammer on a slate block to awaken the sleeper. From these experiments he determined that noise will not pierce a sleeper's consciousness as readily during the first hour or two of sleep. But he forgot to take into account the kind of noise and its relation to the sleeper's environment. A mother of an infant, for instance, may fail to be awakened by a police siren, and yet jump out of bed in an instant at the slightest cry of her baby.

Furthermore, everyone has known the phenomenon of

sleeping through bells, whistles and signals when you know there's no reason for you to be awake—and yet jumping up at the slightest whisper of the alarm clock when you have an important appointment.

Thus, scientists have decided that the degree of motility (plain ordinary tossing) is the best measure of the soundness of sleep. Therefore, your rest is really measured by the percentage of time you remain immobile—but this time does not necessarily have to be consecutive and uninterrupted.

(5) *"The first hour of sleep is the deepest."*

This remark presupposes that there is a single pattern for ideal sleep—that all people sleep alike. Nothing could be farther from the truth. Everyone has his own sleep pattern. Some sleep best early in the night. Some get their best sleep in the wee small hours of the morning. Some people need the traditional eight hours, in bed, at any event, and some people need less. Usually, it's not the hours that you spend in bed but what you do when you are there. Determining one's sleep pattern is perhaps the most important first step to "curing" insomnia.

Understanding your individual sleep pattern will do two things for you: First, it will assure your worrying less about the particular way you sleep. And second, it will enable you to take specific steps toward leveling out your particular sleep curve, by reducing your periods of motility in relation to periods of real rest.

Four Basic Sleep Patterns

There are four basic sleep patterns. None of them is abnormal if the wakeful spells that exist in each aren't too prolonged. In each one it is possible to level out the curve and improve sleep performance within the pattern. Most of you will recognize your basic sleep pattern by the nickname we've given it.

(1) *"The Sheep-Counter."*

This is the fellow who is wide awake at bedtime. He just can't seem to get to sleep during the hour—and it seems like two or three—after he pops under the covers. If he's a busy executive, he resents every minute of wakefulness and this only keeps him awake all the longer.

He's usually the man who is so mentally keyed-up from the day's work, or who keeps working so close to sleep-time, that the wheels keep turning after his head hits the pillow. Once he realizes this is his problem, he can do a lot of things about it.

All these things come under the head of "changing pace". If he is psychologically unable to just stop thinking, he should think about something other than his work. The best prescription, of course, is a warm bath, which pulls the blood away from his overworked cranium. A snack, or a good walk, has the same effect. But if none of these can distract him, he might take up solitaire which will probably bore him out of wakefulness.

The most important thing, however, if you are a sheep-counter, is to realize that the man who pops off to sleep right away may not get any more total sleep than you do. He's just awake at different times. If you naturally sleep best at the end of "your night", the important thing is to make the end longer and the beginning shorter. Your opposite number has the same problem in reverse. We'll call him. . . . . .

(2) *"The Too-Early Bird."*

This is the man who can't seem to sleep beyond five in the morning—when he doesn't really have to get up until seven-thirty. He's understandably annoyed and figures that he's wasting a lot of time lying in bed.

In the first place, if he would simply lie without worrying about it, he'd be getting all the benefits of sleep without being asleep. In the second, it's quite possible that he is actually ready to get up, his system being fully rested. He may just be hungry.

In any event, it's unlikely that he has been awakened by noise, light, or any other external stimuli. In most cases, however, he can prolong his stay in bed somewhat through the use of the various blinders and earmuffs that are the specialties of modern sleep shops. They probably won't contribute to his rest, but they may well make him happier about it. The next variety of sleep pattern is. . . . .

(3) *"The Midnight Thinker."*

This is the one who falls off as soon as his head hits the pillow, only to wake up three hours later and not be able to get to sleep again for an hour or so—and then is reluctant to answer that alarm clock at seven.

Usually the victim wakes up with what he considers a really bright idea that will solve some office situation. Then he thinks about it for awhile under the illusion that he's making some contribution to tomorrow's problems.

Investigation has shown, however, that the chances are overwhelming that this midnight thinker is not thinking as clearly as he imagines. One executive cured himself of this particular delusion by proving that his midnight ideas weren't so good, after all.

He didn't rely on memory. He simply kept a dictating machine beside his bed and relieved his mind of the brilliant thought. Then he rolled over and went back to sleep. But, somehow or other, none of the ideas held up in the cold light of morning and soon he ceased to be bothered by these inspirations. The last basic variety is. . . . .

(4) *"The Rock-and-roller."*

He's the fitful sleeper, who wakes at odd hours through the night. His, like the others', is an average sleep pattern and is no problem unless it becomes extreme. In this case it's almost certain that his difficulties are physical ones. The most common problem is plain, ordinary indigestion. Everyone realizes that actual pain can interrupt sleep, but indigestion can be annoying without actually being painful. Thus, some with uneasy stomachs fail to realize just what's bothering them when a mild indigestion robs them of complete sleep.

Removing the cause is sometimes a matter of experimentation because indigestion is one of the most elusive of man's ailments. We know one sufferer who tried diets, various sizes and shapes of pills, and a variety of other prescriptions—and still couldn't get a sound sleep. Then he stopped smoking and hasn't had an uneasy moment since.

Any one of these patterns is as good as the other, unless the total time of effective sleep falls below a reasonable percentage of the hours in bed. If the curves become too extreme—if, for instance, the too-early bird finds his sleeping time is too short in reference to his waking time—he can, as we have seen, modify his sleep pattern.

What he mustn't do is to continue to kid himself about sleep. He can't do without it and he can't let its elusiveness become a phobia. It's safe to say that if he approaches it the way he would a scientific problem, he'll be able to lick the occupational insomnia that interferes both with his health and his efficiency on his job. END

Symposium on Monte Carlo Methods

EDITED BY HERBERT A. MEYER

Reviewed by Van Court Hare, Jr., Operations Research Laboratory, Stevens Institute of Technology

This book reports papers delivered at the second Symposium on Monte Carlo Methods, held at the University of Florida, March 16 and 17, 1954.

The Monte Carlo Method, which, as the name implies, has to do with probability calculations, is used to obtain approximate answers to complex problems by experimental, rather than by analytic means. In general, a number of discrete evaluations of the problem are made, based upon a series of trial points (or conditions) selected by random sampling from a range of possible trial points. The resulting outcomes are then combined into an estimate of the problem solution desired. To illustrate, one way to determine the probability that 7 will occur when 2 dice are thrown is to calculate it from a knowledge of how die faces can combine. Another way is to roll two dice a number of times and observe the proportion of times 7 turns up. The Monte Carlo Method is of the latter type, except that the dice would be rolled synthetically by simulating the actual die outcomes with numbers generated by random sampling from a list (probability distribution) of possible outcomes. The proportion of 7's that turned up in the sampling would give an estimate of the "true" answer.

Typical problems for which the method is useful are: diffusion rate or position of particles at different periods of time (radioactive decay problems), replacement and failure calculations (life insurance, system reliability problems), comparing different bombing strategies, comparing different product specifications, testing different control system plans (feasibility problems), and many others. The method has gained favor with researchers because it yields rough solutions to complicated problems in a short time, either by hand or by computer. Furthermore, application of the method, which amounts to building a probability "model" of the process presented by the problem to be solved, often yields insight the researcher can use to obtain an analytic solution.

As in most sampling techniques, problems of Monte Carlo application involve the reduction of variance in estimates (i.e. solutions) to problems, questions about the number of trials (or sample items) to take for given accuracy in results, and different means for increasing sampling efficiency. These subjects are treated by papers presented at the Symposium. Of particular interest are machine methods for carrying out Monte Carlo solutions.

Although knowledge of statistics, probability, and calculus is assumed, the reader not already familiar with Monte Carlo methods can derive benefit from this volume. It is recommended for Physicists, Chemists, Systems Design Engineers, and Operations Research workers, as well as statisticians. Other research workers should be aware of this powerful tool and its possibilities, and may derive benefit from a look at papers presented, particularly those by Dr. Herman Kahn ("Use of Different Monte Carlo Sampling Techniques") and Dr. Alwin Walther ("Experiments and Models for the Monte Carlo Method").

The book is one of Wiley's series in Applied Statistics; authors of papers include the best known names in the statistical field. An excellent (100 page) Bibliography and Index enhance the book's value as a reference work.

John Wiley and Sons, Inc., New York, N. Y. (1956) 382 pages, $7.50.

Elementary Nuclear Theory

BY HANS A. BETHE AND PHILIP MORRISON

Reviewed by Dr. R. C. Vickery, Horizons Incorporated.

As with the first edition, this book is not meant to be a textbook of the theory of atomic nuclei. It is quoted by the authors to be merely a selection of certain topics in the theory, treated in an elementary way. And this, again, the second edition does fulfill.

Nine years have elapsed between the two editions of this textbook, and the fact that these nine years have covered a period of intense development in nuclear theory and application would seem to necessitate an almost new approach to the subject, but essentially the greatest change in the second edition is the devotion of more space to the structure and reactions of heavy nuclei. The chemistry involved is, however, handled better in this edition than in the first and gives a more complete coverage. Chapter VII in this book of twenty-one chapters is probably the most direct edition, since it covers π mesons in which there has been much development and study since the 1947 edition of this book.

The methods of delineating physical properties of nuclear "components" is good and may be lucidly read and followed. However, there would appear to be too much

Seven articles on the administration of research . . .

COMING IN THE DECEMBER ISSUE OF ADMINISTRATIVE SCIENCE QUARTERLY

REFLECTING its continuing interest in the administration of professional and intellectual activities, Volume 1, Number 3 of this new scholarly journal will focus on research, with the following articles:

The Administrative Process of Contract and Grant Research. BY ALAN C. RANKIN

Nine Dilemmas in Industrial Research. HERBERT A. SHEPARD

Some Social Factors Related to Performance in a Research Organization. DONALD C. PELZ

Administration of Research in a Research Corporation. JOHN L. KENNEDY AND G. H. PUTT

Status, Prestige, and Esteem in a Research Organization. CLOVIS SHEPHERD AND PAULA BROWN

Teamwork and Creativity in Research. GEORGE P. BUSH AND LOWELL H. HATTERY

Development of Managers—Training in a Research Division. R. M. CAVANAUGH

ORDER FROM

Administrative Science Quarterly
Graduate School of Business and Public Administration
Cornell University,
Ithaca, N. Y.

$2.00 a copy
$7.50 a year

management affairs

Seven of the most popular articles for improving technical management published in RESEARCH & ENGINEERING in recent months have been reprinted, including five by Luis J. A. Villalon, our Management Affairs Editor. Available for 25¢ each, they are listed below.

- LIMIT THEOREMS: Practical Tool for Project Evaluation
- THE DIFFICULT PERSONALITY PROBLEM IN R & D
- EXECUTIVE HEALTH: 14 Ways to Maintain It
- TURN YOUR IDEAS INTO ACTION
- HOW'S YOUR STAFF EFFICIENCY?
- HOW'S YOUR ORGANIZATION QUOTIENT?
- TIME MANAGEMENT FOR THE RESEARCH EXECUTIVE

Reprints of the above articles on management problems are available for twenty-five cents each. Send check or money order to RESEARCH & ENGINEERING, *77 South St., Stamford, Conn.*

outlining of material, rather than the production of a "meaty" book, and in many instances the book is very jerkily written, the syntax not flowing as smoothly as it might. References to other volumes and journals are given within the text, and the Reviewer is not too sure whether this is a good practice. In many cases, a search of several pages is necessary in order to relocate a reference which one has previously noted. Were these references footnoted, this task would be considerably easier.

The book in general is divided into three parts, covering Descriptive Theory of Nuclei, Quantitative Theory of Nuclear Forces, and Complex Nuclei. The distribution of chapters between these parts is uneven—the first taking seven chapters, the second, eleven, and the third, three. However, this apparent maldistribution is not basically apparent in reading, since the general development of the theme is good.

As an appendix there is given a table of nuclear species, the data in which are generally accurate, but a number of important points of disagreement are obvious above the level of potassium. The existence of these disagreements is noted by the authors and it is then left apparently to the reader to decide which values—those given here or those given by other workers—are more appropriate. Generally the book is well produced, binding and typescript are good, and there are relatively few typographical errors. Generally the book can be recommended as an adjunct to the library of those who have to teach this subject. However, the Reviewer would hesitate to recommended this as a book for students. *John Wiley and Sons, Inc., New York, N.Y. (1956), 2nd edition, 264 pages, $6.25.*

The United States Patent System

BY FLOYD L. VAUGHAN

Reviewed by Lawrence I. Field, Patent Attorney, Horizons Incorporated.

This book traces in a most readable fashion the histories of abuses which have arisen through the creation of patent pools, patent consolidations, license agreements and the control of supplementary products. Each is discussed from the development of an early attitude which emphasized the monopoly grant aspect of a patent and protected individual patents to the present attitude emphasizing the public interest and condemning antitrust or other misuse of the patent monopoly by combinations holding large numbers of patents in a limited field.

Other individual chapters are devoted to a discussion of cartels, prolonged monopoly, suppression of patents, and discouragement of inventors. The author proposes a number of remedies to correct what he conceives to be the evils which have fallen on the patent system in this country as a result of the shift from the individual inventor to the teams of hired inventors performing research for large corporations, and producing defensive patents which hem in the inventions of other inventors.

The text is provided with footnotes to most, if not all, of the leading cases on patents, and the author makes liberal use of quoted excerpts from these decisions. One unfortunate result of the timing of this text is that only a few decisions rendered subsequent to the passage of the Patent Act of 1952 could be included in the text, although the author has seen fit to criticize portions of the Act in advance of any judicial interpretation indicating the scope to be given to the new legislation.

One of the more interesting suggestions proffered by Mr. Vaughan is the introduction of a defense to an infringement action based on non-use or suppression of the patent by the patent owner. This defense would be open only to the inventor-owner and not to his assigns, or, in other words, to patents which are the property of corporations. When closely scrutinized, this appears to be an ingenious scheme to bring compulsory licensing into this country under another disguise.

The suggestion that large corporations deliberately suppress patents because of existing capital investment in equipment, advertising, and materials, is not universally correct. Indeed, there have recently been published a number of articles directed to corporations owning large numbers of patents outlining methods of recovering the assets which have lain dormant in the form of unused patents. At least one industrial consultant is carrying on a vigorous program to obtain contracts to examine the unused patents of large companies in an attempt to rescue from the discard heap those worthy of a second chance.

The philosophy of this text reveals sympathy with the growing tendency toward corrective action by the courts of the abuses spawned by the misuse of the monopoly granted under the patent system.

It seems unfortunate to this Reviewer that the probable consequence of recent judicial decisions requiring compulsory licensing to anyone, or large blocks of patents on either a royalty-free or reasonable royalty basis, will probably tend to dry-up the previous patent disclosures of the results of research by the larger corporations but this will probably be regarded with approval by the author of this work.

In summary, the author has presented a comprehensive picture of the change in judicial attitude toward the use made of patents by corporate-owners, and of the increasing weight given to the provision of the Sherman Act and the Clayton Act in the cases alleging a use of combinations of patents "in restraint of trade". The book will prove a handy reference for persons seeking a general familiarity with the judicial history of patent cases prior to the 1952 Patent Act.

University of Oklahoma Press, Norman, Oklahoma, 336 pages, $8.50.

Reference Texts

The Sun and its Influence, by M. A. Ellison, The Macmillan Co., New York, N.Y., 235 pp., $4.50.

A factual account of the structure and characteristic activity of the sun, including explanations of natural occurences and descriptions of the new instruments for the study of the solar atmosphere. New knowledge about solar flares and the showers of particles which reach us from the sun, and their influence upon the earth's magnetism are also dealt with. Neither too advanced for those with a knowledge of elementary physics, nor too simple to be read profitably by workers in other sciences.

Petroleum Production Engineering, by Lester Charles Uren, McGraw-Hill Book Co., Inc., New York, N.Y., 792 pages, $12.00.

A volume designed to serve as a text for petroleum engineering students and as a comprehensive review of the processes, methods and equipment used in this important phase of the petroleum industry for practicing engineers, geologists, oil company executives and others engaged in the petroleum and natural gas industries. Hundreds of technical papers have been reviewed for this edition, and the author has also drawn upon information gained in supervising many petroleum-technology research projects.

Ionized Gases, by A. von Engel, Oxford University Press, New York, N.Y., 280 pages, $6.75.

This book should serve as a valuable and up-to-date introduction to the properties of ionized gases, both for physicists and engineers, and as a useful reference book for those doing research in the field. The basic theory of various types of discharges is described in detail, and numerous figures and tables of value are given. Emphasis is on a physical understanding of the mechanism, but refinements of the theory are mentioned briefly.

Automatic Process Control, by Norman H. Ceaglske, John Wiley & Sons, Inc., New York, N. Y., 230 pages, $6.75.

A book written directly for the chemical engineer, this presents and applies the basic mathematical principles of process control in an elementary form. In addition to a review of principles and their application to simple control systems, methods for calculating the dynamic response of processes are also included. Examples and illustrations are given to demonstrate the use of equations, and typical problems are offered at the end of each chapter.

Hydraulic Research in the United States, National Bureau of Standards Miscellaneous Publication 218, by Helen Middleton, 216 pages, $1.50.

Compiled from reports by various hydraulic and hydrolic laboratories in the United States and Canada. Projects are listed chronologically with the assigned numbers repeated for identification purposes until a project is completed. Projects numbered from 2255 on are reported for the first time, and all projects are in an active state unless otherwise noted.

A Survey of Properties, Applications, and Production Methods—Fused-Quartz Fibers, by Nancy J. Tighe, National Bureau of Standards Circular 569, 26 pages, 25 cents.

A summary, including a bibliography, of a literature survey covering the properties related to actual use of the fibers. Discusses applications, production and fabrication methods, and mechanical and other properties of fused-silica fibers.

Temperature; Its Measurement and Control in Science and Industry, Vol. II, edited by Hugh C. Wolfe, Reinhold Publishing Corp., New York, N.Y., 467 pages, $12.00.

Proceedings of the Third International Symposium on Temperature. Twenty-four papers, each prepared by an expert, cover significant new developments in the techniques of determining temperatures over the entire ranges from .001°K to the core of an atomic explosion. Details of the 1954 revision of the international temperature scale, new developments in temperature measurements in engineering, and other valuable information make this a worthwhile addition to your reference shelf.

Effective Supervision, by M. Brown, The MacMillan Company, New York, N. Y., 255 pp., $4.50.

Although not written with the supervision of research or engineering personnel in mind, this book will help your group obtain greater productivity in the office or in the lab. It explains clearly supervisory duties and responsibilities and points the way to developing efficient and effective systems of operation. Covers the basic responsibilities of the supervisor, how to carry them out, how to make important improvements through the use of method analysis, job analysis and task analysis. Also covers techniques for developing job competence through proper training and selection of employees, and how to establish work programs based on appraisal of physical facilities and employee abilities.

Something of highly unusual interest is happening in

COMMERCIAL ADVANCED DEVELOPMENT ENGINEERING

Up to $15,000

To build a commercial advanced development section, RCA offers extremely interesting positions to creative engineers and physicists. Diversified work in bandwidth compression, computers, applied physics, communications. We can fit your special interests. Senior and Junior engineers are needed. For confidential interview day or evening: call collect—Mr. R. A. Wallace, at Camden, N.J., WOodlawn 3-8000. Or send resume to: Mr. John R. Weld, Employment Manager, Dept. Z-8L, Radio Corporation of America, Camden 2, N.J.

RADIO CORPORATION OF AMERICA
Commercial Electronic Products

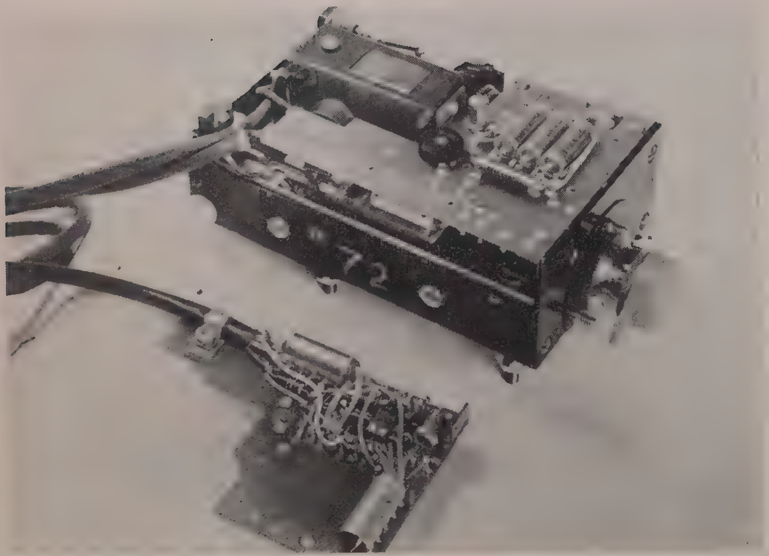
YARDSTICKS

"Stops" Vibration Testing

New equipment shake tests can be watched in slow motion or visually "stopped" in any selected cyclic position by synchronizing a strobe light with the "Slip-Sync". It can synchronize the light with tables that shake at from 5 to 10,000 cps.

Developer: Chadwick-Helmuth Co., 472 East Duarte Road, Monrovia, California

For more data circle 31

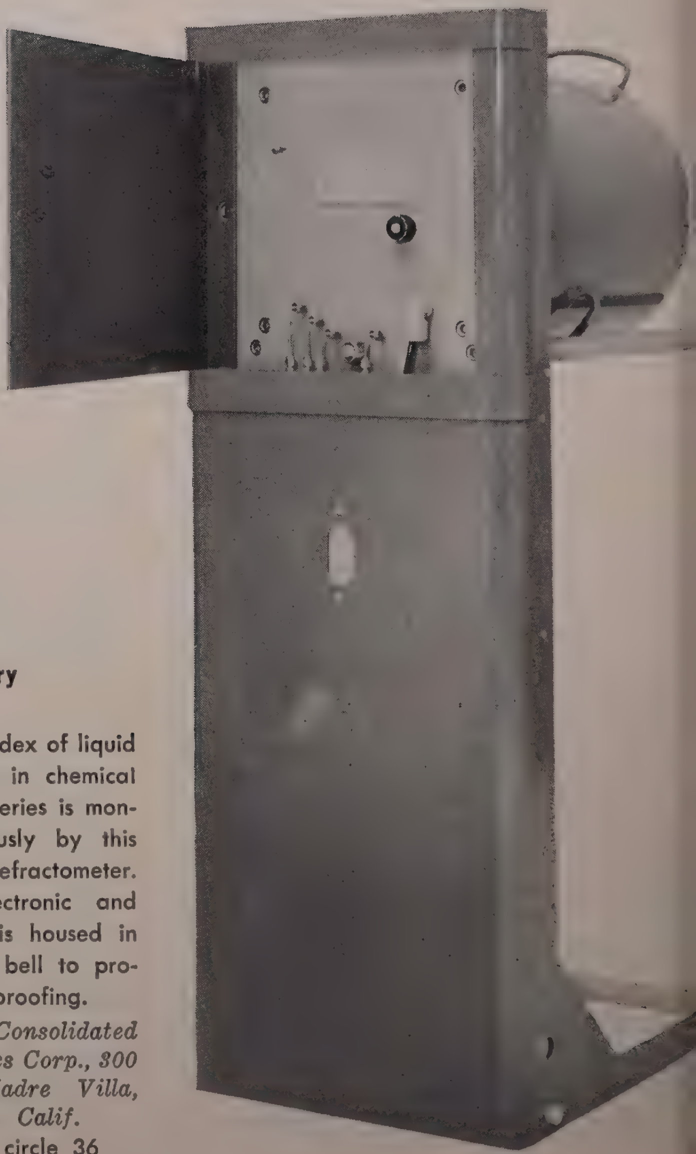


Withstands 100g

This 2¼ oz. electronic timing generator for a Wollensak missile camera can withstand acceleration loads of 100g. It can pulse at rates from once to 3000/sec and was developed by the Missile Systems Div., Lockheed Aircraft Company.

Manufacturer: Electromation Co., 116 So. Hollywood Way, Burbank, Calif.

For more data circle 34 on p. 48.



Monitors Refinery Continuously

The refractive index of liquid process streams in chemical plants and refineries is monitored continuously by this Type 38-202 refractometer. The entire electronic and optical system is housed in a pressed-steel bell to provide explosion proofing.

Developer: Consolidated Electrodymanics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

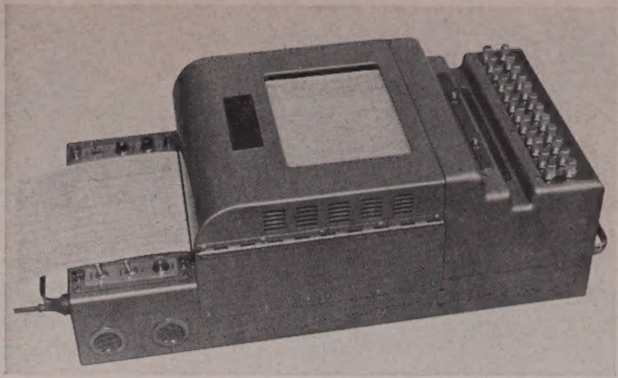
For more data circle 36

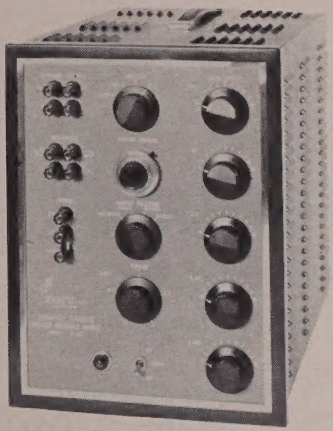
Xerographic Oscillograph

No recording pens are needed in this oscillograph, which uses the xerographic process of the Haloid Company, Rochester, N.Y. It can be used to take flight data of missiles and new aircraft and in many other laboratory testing set-ups.

Manufacturer: Instruments, Inc., Tulsa, Okla.

For more data circle 32 on p. 48.



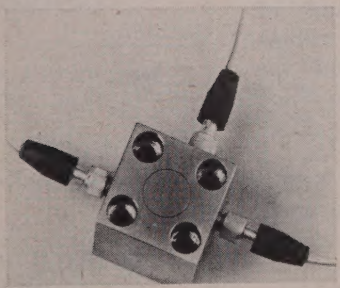


Standard Voltage Source

Maximum drift per year of this secondary standard reference source is only 0.02%. Initial accuracy is 0.01%. Output ranges from +111.112 to −111.112 v d-c in steps of one millivolt. It can also be used for meter and transducer calibration.

Developer: Epsco, Inc., 588 Commonwealth Avenue., Boston 16, Mass.

For more data circle 35 on p. 48.

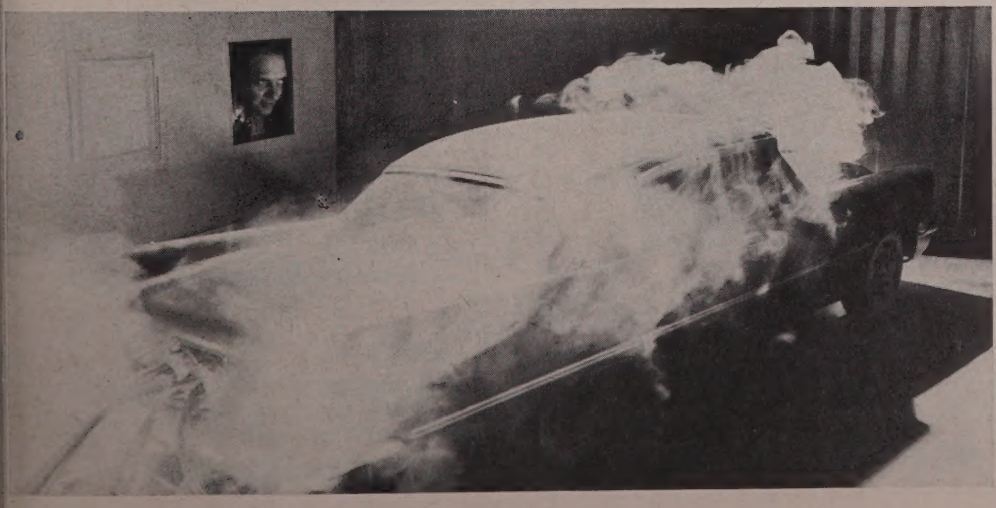


High-Temperature Accelerometer

Measuring three mutually perpendicular accelerations simultaneously, this small accelerometer will operate accurately from −65°F. to 350°F. It replaces three separate instruments. Frequency response is from 25 to 20,000 CPS.

Developer: Gulton Industries, Inc., Metuchen, New Jersey

For more data circle 33 on P. 48.



Fins Aren't Just for Fish

The fins sprouting on all the new cars aren't just to catch madam's eye. They help steady the car in strong crosswinds at highway speeds. Wind pressure recordings taken at 100 points on the surface of this scale model '57 sedan prove the fins' value. The smoke was introduced into the University of Detroit's wind tunnel to make the air stream visible.

Test Developer: Chrysler Corp., Detroit 31, Michigan

Research Reports

Reports in this section may be obtained directly from the Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C., unless another source is stated.

Magnesium Alloys

An Air Force study of the constitution and development of magnesium alloys. The research is devoted to the constitution of alloys in the solid state in the magnesium corner of the magnesium-lithium-aluminum and magnesium-lithium-zinc alloy systems, development of magnesium alloys with a low alloy content for high ductility sheet, and study of single crystals of magnesium alloys. Diagrams are presented to show the constitution at 500° and 700° F for the magnesium-lithium-aluminum and magnesium-lithium-zinc alloy systems. MAGNESIUM ALLOY RESEARCH STUDIES, *PB 111-762, 138 pages $3.50*

Low-Alloyed Steels

The relationships between microstructures formed with various cooling rates and austenitizing temperatures and properties at 700° to 1200°F for three low-alloyed steels are analyzed in this report.

The three steels are Ni-Cr-Mo (SAE 4340), 1.25Cr-Mo-V ("17-22-A"S), and 3-Cr-Mo-W-V (H-40). Results indicated that the fully bainitic structures which were predominantly in the upper bainite had maximum strength over the range of testing temperatures. Best combinations of strength and ductility were obtained when the largest sections were normalized from the lower austenitizing temperatures.
A SURVEY OF THE EFFECT OF AUSTENITIZING TEMPERATURE AND RATE OF CONTINUOUS COOLING ON THE STRUCTURE AND 700° F PROPERTIES OF THREE LOW-ALLOYED STEELS, PB 121149, 78 pages, $2.00.

Rubber Compounds Evaluated

Various commercial and experimental rubber compounds for high-temperature use in contact with newly developed hydraulic fluids are evaluated in this Air Force report. Results indicate that present elastomer compounds are incapable of service in the fluids for more than 48 hours at 400° F. Some acrylic rubber compounds showed promise up to 550° F. but aged elongations are so low that their usefulness is limited. Others of the blended acrylic types showed a fair balance of properties after aging.
DEVELOPMENT OF A RUBBER FOR HIGH-TEMPERATURE SERVICE IN CONTACT WITH EXPERIMENTAL HYDRAULIC FLUIDS, *PB 111766, 18 pages, $.50*

Fuming Nitric Acid

The report of the Air Force's investigation of materials for handling fuming nitric acid, a rocket fuel, is divided into two sections. The first deals with the results of polarization and corrosion studies of galvanic couple systems with WFNA fuel, erosion-corrosion studies in WFNA, guinea pig container tests in WFNA, and corrosion-fatigue tests.

The second part deals with a study of the effect of the ratio of the vapor volume to total volume of the sample, and the temperature on the rate of decomposition and equilibrium decomposition pressure of all results obtained on the pure acid.
MATERIALS FOR HANDLING FUMING NITRIC ACID WITH REFERENCE TO ITS THERMAL STABILITY. *PB 111950, 140 pages, $3.50*

PLEASE USE THIS FORM BEFORE JAN. 1

ADDITIONAL INFORMATION FORM 11-56

CLIP OUT AND MAIL TO Research & Engineering
103 Park Avenue, New York 17, N.Y.

Please type or print

For more information on products or ads in this issue, circle appropriate number.

	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
1	6	11	16	21	26	31	36	41	46	51	56	61	66	71	76
2	7	12	17	22	27	32	37	42	47	52	57	62	67	72	77
3	8	13	18	23	28	33	38	43	48	53	58	63	68	73	78
4	9	14	19	24	29	34	39	44	49	54	59	64	69	74	79

Name ....

Title ....

Company ....

Company Address ....

Zone No.

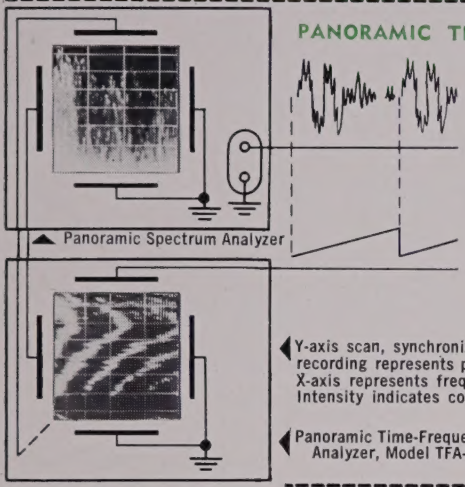
ADVERTISING INDEX

FOR MORE INFORMATION ON ADVERTISEMENT ON THE OPPOSITE PAGE CIRCLE 50 ON PAGE 48.

proved performers

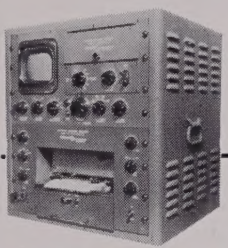
IN PLANTS AND LABORATORIES

designed and perfected by PANORAMIC ...the leader:



PANORAMIC TIME-FREQUENCY ANALYZER, Model TFA-1
A new instrument designed to perform as a companion instrument to various Panoramic Spectrum and Waveform Analyzers, Panoramic Time-Frequency Analyzer TFA-1 provides a complete history if the time occurrence of transient waveform components, in addition to frequency and amplitude information.

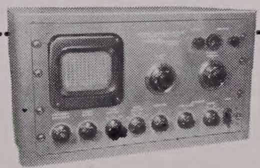
Y-axis scan, synchronized to loop recording represents playback interval. X-axis represents frequency distribution. Intensity indicates component level.



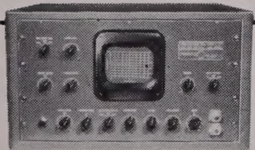
Panoramic Time-Frequency Analyzer, Model TFA-1

PANORAMIC SUB-SONIC ANALYZER, Models LF-1 and LF-2 for SUB-SONIC WAVEFORM ANALYSIS 0.5 cps—2250 cps features 0.1 cps resolution, 40 db amplitude range, high sensitivity, permanent-spectrum recordings.

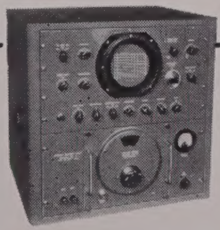
PANORAMIC SONIC ANALYZER, Models LP-1 and AP-1 for AUDIO FREQUENCY WAVEFORM ANALYSIS 20 cps—20 kc feature direct reading waveform analysis in only one second, 60 db dynamic range, simple operation.



PANORAMIC ULTRASONIC ANALYZER, Model SB-7a for ULTRASONIC WAVEFORM ANALYSIS 1 kc—300 kc features continuous variable scan width 0-200 kc continuously variable resolution 2 kc—500 cps, direct reading frequency and amplitude scales.



PANALYZOR, Model SB-8b and PANADAPTOR, Model SA-8b for RF, VHF, and UHF SPECTRUM ANALYSIS. Each model available in three types with maximum sweep widths of 200 kc, 1 mc, and 10 mc, and maximum resolution of 50 cps, 200 cps, and 9 kc respectively. Numerous other models and types also available to suit practically every special need.



PANORAMIC SPECTRUM ANALYZER, Model SPA-1 microwave spectrum analysis 50 mc—4000 mc—Sensitivity: up to —100 dbm; SWEEPWIDTH: 10 mc continuously reducible to 0 mc; RESOLUTION: 9 kc—100 kc, continuously variable; SCAN RATES: 1 cps—60 cps, continuously variable; FREQUENCY COVERAGE: tuning heads RF-2 50—250 mc and RF-3 220—4000 mc.

Also makers of Sweep Generators and Frequency Calibrators. Inquiries invited for development of special Panoramic analyzers.

PANORAMIC RADIO PRODUCTS, INC.
8-10 S. Second Ave., Mount Vernon N.Y.
MOunt Vernon 4-3970
Cables: Panoramic, Mount Vernon, N. Y. State

for accurate spectrum analysis from sub-sonic through microwaves

Pioneers in the field of spectrum analysis . . . through the years Panoramic has demonstrated leadership . . . and Panoramic instruments have been proven unexcelled for research development and production applications requiring accurate high-speed spectrum of waveform analysis.

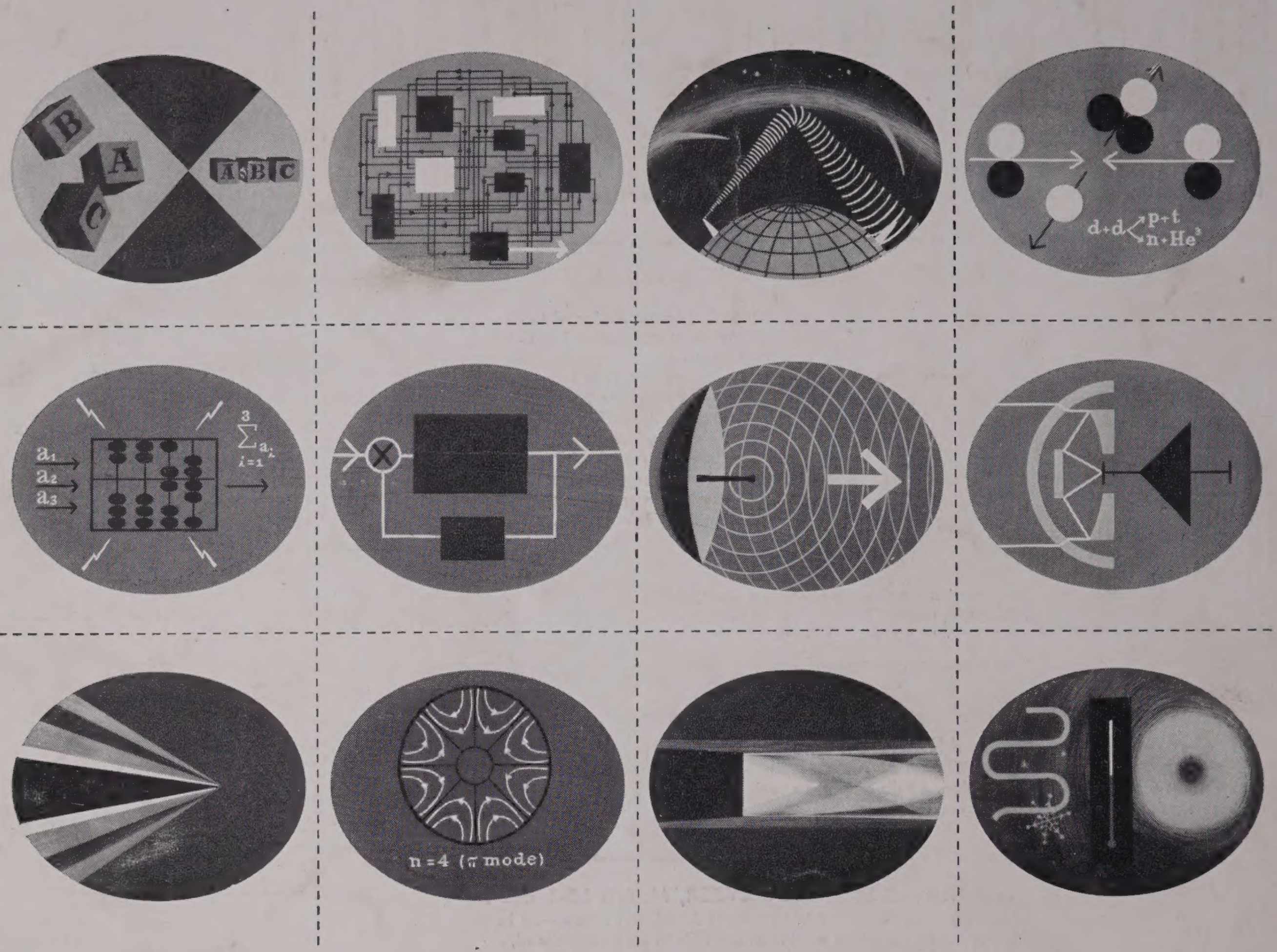
Whatever your problem, from subsonic through microwave analysis, there is a Panographic analyzer to answer your needs. Operation is simple and reliable. Design and construction are the finest. Many models are used in military applications.

Day in and day out, Panoramic Instruments play a vital part in monitoring communications channels . . . telemetering analysis . . . vibration and sound studies . . transmitter analysis . . . FM deviation measurements . . . microwave spectrum analysis . . . servo analysis.

WRITE TODAY FOR COMPLETE TECHNICAL DATA AND PRICES

THE MARK OF THE ORIGINAL · PANORAMIC

PANORAMIC
RADIO PRODUCTS, INC.



Variety of Technical Fields

These illustrations are symbolic of some of the scientific and engineering fields of endeavor which are essential ingredients in the broad range of technical programs that are in progress at The Ramo-Wooldridge Corporation. Illustrated are: Information Theory, Systems Analysis, Communications, Nuclear Physics, Electronic Computers, Servomechanisms, Electromagnetic Propagation, Infrared, Aerodynamics, Microwaves, Propulsion, and Thermodynamics.

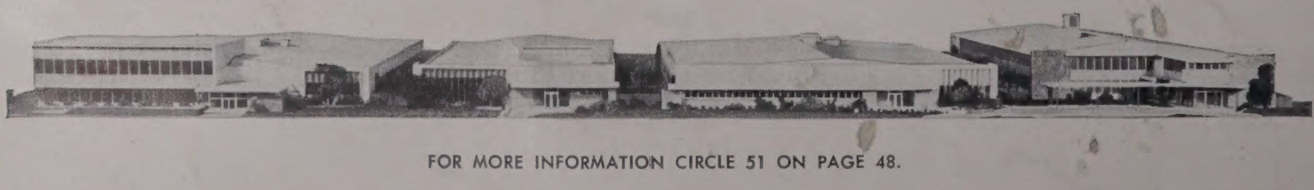
The requirement for technical competence in a wide variety of fields is a significant characteristic of systems engineering work. At R-W this requirement is particularly important because of our emphasis on the development of systems having a high content of scientific and engineering newness.

Our current military contracts support a number of advanced programs in the fields of modern communications, digital computing and data processing, fire control and navigation systems, instrumentation and test equipment. In the guided missile field, Ramo-Wooldridge has technical direction and systems engineering responsibility for the Air Force Intercontinental and Intermediate Range Ballistic Missiles. Our commercial contracts are in the fields of operations research, automation, and data processing. All of this work is strengthened by a supporting program of basic electronic and aeronautical research.

Scientists and engineers whose training and experience are in these or related fields are invited to explore the openings at The Ramo-Wooldridge Corporation.

The Ramo-Wooldridge Corporation

5730 ARBOR VITAE STREET • LOS ANGELES 45, CALIFORNIA



FOR MORE INFORMATION CIRCLE 51 ON PAGE 48.